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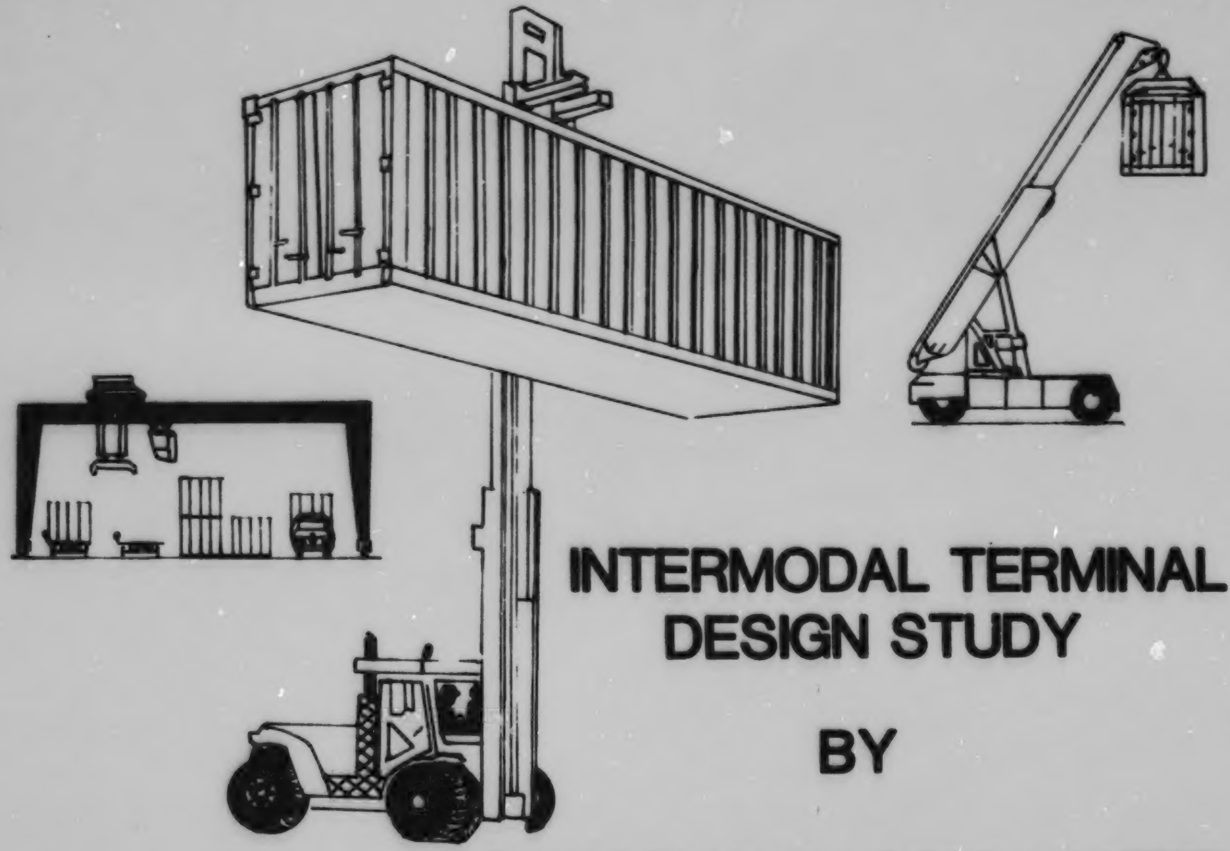
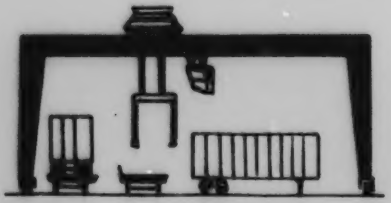


INTERMODAL TERMINAL DESIGN STUDY

BY

CANADIAN PACIFIC LIMITED
MARCH 1983



FINAL REPORT

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PREPARED FOR THE TRANSPORTATION DEVELOPMENT CENTRE

TP-4059E

INTERMODAL TERMINAL DESIGN STUDY

FINAL REPORT

PREPARED BY

CANADIAN PACIFIC LIMITED

FOR

THE TRANSPORTATION DEVELOPMENT CENTRE

MARCH 1983

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REPORT DOCUMENTATION FORM

1. Transport Canada Report No. TP 4059E	2. TDC Project No 8937	3. Recipient's Catalogue No
4. Title and Subtitle INTERMODAL TERMINAL DESIGN STUDY Final report		5. Report Date March 1983
		6. Performing Organization Report No
7. Author(s) Ives C.J.M., Dale J.C. et al.		8. Transport Canada File No D1465-285-15
9. Performing Organization Name and Address CANADIAN PACIFIC LIMITED P.O. Box 6042, Station "A" Montréal, Québec		10. DSS File No 09SD T8200-8-8552
		11. DSS or Transport Canada Contract No OSD79-0045
12. Sponsoring Agency Name and Address TRANSPORTATION DEVELOPMENT CENTRE (TDC) 1000 Sherbrooke St. W. Suite 2421 Montréal, Québec H3A 2R3		13. Type of Report and Period Covered Sept. 1979 - March 1983
		14. Sponsoring Agency Code TDC 8937
15. Supplementary Notes Appendices separately bound		16. TDC Project Officer T. Smith (M. Tapiero)

17. Abstract

This study was undertaken to make recommendations for the design of intermodal terminals taking into account land area, cost and state-of-the-art procedures, facilities and handling equipment.

The project team made an in-depth study of one major Canadian terminal to determine the traffic flow of both trains and tractors in and out of the terminal, the handling cycle of equipment, and, using the information gathered, the operation of the terminal was simulated. The team also studies operating strategies and information management systems. Finally, terminal expansion and design options were investigated.

It was found that the terminal under study with circus-loading of trailers is adequate for a capacity up to 100,000 units/year. Beyond this point, however, side-handling equipment for trailers should be considered and the ramps removed. This will allow more room within the working area for storage. A double-entry track configuration would allow the road engine to perform some of the car switching, thus increasing the turnover possible within the day. Beyond a volume of 225,000 units/year, a new facility should be considered.

18. Key Words Intermodal, Terminals, Traffic flow, Handling cycles, Management, Design, Expansion	19. Distribution Statement Limited number of copies available from TDC or CP Ltd.

20. Security Classification (of this report) Unclassified	21. Security Classification (of this page) Unclassified	22. No. of Pages 70	23. Price nil

DC CDT 79 005

FORMULE DE DOCUMENTATION POUR RAPPORT

1. N° du rapport Transports Canada TP4059E	2. N° de l'étude — CDT 8937	3. N° de catalogue du destinataire

4. Titre et sous-titre INTERMODAL TERMINAL DESIGN STUDY Final report	5. Date du rapport Mars 1983
	6. N° du rapport de l'organisme executant
7. Auteur(s) Ives C.J.M., Dale J.C. et al.	8. N° de dossier Transports Canada D1465-285-15
9. Nom et adresse de l'organisme executant CANADIEN PACIFIQUE LIMITEE Boîte postale 6042, succursale "A" Montréal, Québec	10. N° de dossier — ASC 09SD T8200-8-8552
	11. N° de contrat — ASC ou Transports Canada OSD79-0045
12. Nom et adresse de l'organisme parrain Centre de Développement des Transports 1000 ouest, rue Sherbrooke, suite 2421 Montréal, Québec H3A 2R3	13. Genre de rapport et periode visee Sept. 1979 - mars 1983
	14. Code de l'organisme parrain CDT 8937
15. Remarques additionnelles Les annexes se trouvent sous pli séparé	16. Agent de projet — CDT T. Smith (M. Tapiero)

17. Resume

Cette étude a été entreprise afin de faire des recommendations sur la conception de terminaux intermodaux en tenant compte de la surface du terrain, du coût, des procédures d'opération et de l'équipement.

L'équipe du projet a fait une étude exhaustive d'un grand terminal canadien afin de déterminer le débit de circulation des unités de trains et tracteurs entrant et sortant du terminal, le cycle de manipulation des équipements de chargement et, à l'aide de l'information recueillie, l'opération du terminal a été simulée. L'équipe a aussi étudié les stratégies d'opération ainsi que les systèmes de gestion d'information. Enfin, l'agrandissement et les options de conception des terminaux ont été examinées.

Il en a été conclu qu'avec un volume de 100,000 unités par année, le système de chargement des remorques par rampes est adéquat. Au delà de ce volume, toutefois, l'on devrait envisager un système de chargement des remorques par le côté et enlever les rampes. Ceci donnerait plus d'espace pour l'entreposage d'unités dans l'aire de travail. Une configuration des rails à entrée et sortie doubles permettrait à la locomotive de route d'effectuer une partie des transferts de trains, augmentant d'autant la capacité du terminal durant la journée. A compter d'un volume de 225,000 unités par année, de nouvelles installations sont à recommander.

18. Mots-clés Intermodal, Terminaux, Circulation, Cycles de chargements, Gestion, Conception, Expansion	19. Diffusion Un nombre limité de copies sont disponibles au CDT ou au CP Ltée

20. Classification de sécurité (de ce rapport) non-classifié	21. Classification de securité (de cette page) non-classifiée	22. Nombre de pages 70	23. Prix nul

ACKNOWLEDGEMENTS

The team members of this project wish to acknowledge the advice and support of the following organizations who contributed of their time and expertise to this study:

CP Limited
  - CP Rail - Intermodal Services
  - Information Systems
  - CP Rail - Operations Development
  - CP Rail - Communications
  - Systems Services

Transport Canada - Transportation Development Centre

Railway Advisory Committee (RAC)

CN Rail
  - Intermodal Services
  - Operations Research & Industrial Engineering

U.S. Federal Railways Administration, Washington, D.C.
Office of Freight Systems

Systems Control Inc.

Mersey Docks & Harbours Board - Great Britain

British Rail Freightliners

Luke, Malone & Associates Ltd. (Graphics)

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Appendix I: Terminal Capacity Analysis
Appendix II: Terminal Management System
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1. INTRODUCTION

Intermodal truck/rail freight systems are designed to provide door-to-door service for containers and trailers. This service is based on a railway line-haul for long distances between major terminals and truck pick-up and delivery for the short distances to the shipper and consignee, the only points where the contents are handled. Figure 1.1 outlines the work flows in a typical intermodal terminal.

In Canada, two major railroads operate intermodal freight systems from coast to coast, backed by a growing fleet of trailers and containers on flat cars.

This intermodal terminal design study was undertaken as a shared-cost joint-responsibility project of Transport Canada and CP Limited under the auspices of the Railway Advisory Committee. The original mandate of the study was confined to the transfer and storage systems within the terminal.

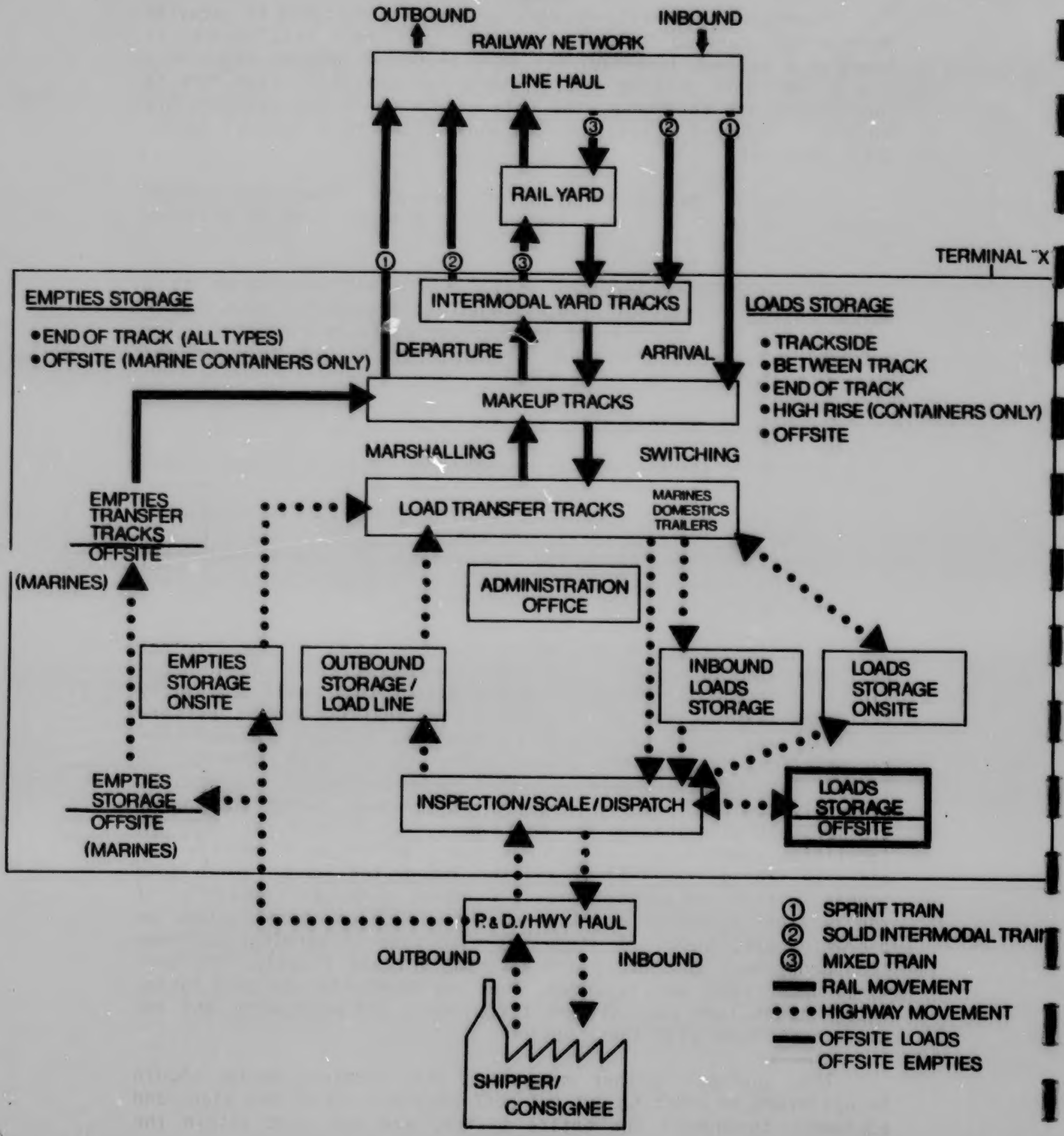
The purpose of this study was to:

- document state-of-the-art procedures, facilities and equipment,
- analyse terminals for potential improvements in throughput capacity, service level, and cost.
- make recommendations for the design of future facilities using state-of-the-art techniques, taking account of land areas and costs and other restrictions.

To achieve these objectives, a thorough study of one terminal was undertaken to determine the characteristic traffic flows, handling equipment cycle times and other factors that would ultimately influence terminal design. A specific terminal designated as Terminal 'X' was chosen because it combines the following useful characteristics. Its present volume makes it a large terminal in Canada. This terminal could be slated for expansion if required. It presently combines track configurations for both circus-loading of trailers and side-loading for containers, and finally, the storage facilities combine the transfer scheme (with remote on-site and off-site storage facilities) and the integrated scheme (with some storage within the working area). Further, a manual simulation of the terminal operation highlighted the effect of these factors on operating procedures. A study was also made of terminal information management procedures and alternatives and finally, the terminal under study was expanded, then new terminals designed taking into account land use, different equipment and procedures and the costs associated with these options.

This approach further emphasized that terminal design should be optimised in order to get the best possible use of the plant and equipment throughout the entire system, and not just within the terminal.

Terminal Operating Elements
Figure 1.1


OUTBOUND
INBOUND
RAILWAY NETWORK
LINE HAUL
③
②
①
RAIL YARD
①
②
③
TERMINAL "X"
EMPTIES STORAGE
• END OF TRACK (ALL TYPES)
• OFFSITE (MARINE CONTAINERS ONLY)
INTERMODAL YARD TRACKS
LOADS STORAGE
• TRACKSIDE
• BETWEEN TRACK
• END OF TRACK
• HIGH RISE (CONTAINERS ONLY)
• OFFSITE
DEPARTURE
ARRIVAL
MAKEUP TRACKS
MARSHALLING
SWITCHING
EMPTIES TRANSFER TRACKS
OFFSITE
(MARINES)
LOAD TRANSFER TRACKS
MARINES
DOMESTICS
TRAILERS
ADMINISTRATION OFFICE
EMPTIES STORAGE ONSITE
OUTBOUND STORAGE / LOAD LINE
INBOUND LOADS STORAGE
LOADS STORAGE ONSITE
EMPTIES STORAGE
OFFSITE
(MARINES)
INSPECTION/SCALE/DISPATCH
LOADS STORAGE
OFFSITE
P. & D./HWY HAUL
OUTBOUND
INBOUND
SHIPPER/
CONSIGNEE
① SPRINT TRAIN
② SOLID INTERMODAL TRAI
③ MIXED TRAIN
RAIL MOVEMENT
• • • HIGHWAY MOVEMENT
OFFSITE LOADS
OFFSITE EMPTIES

2. BACKGROUND

A systems engineering approach was used for this study based on a multi-disciplinary team drawn from within CP Limited.

The project duration was from May 1979 to the end of 1981, and had six milestone stages (study objectives, review state-of-the-art, initial design study, advanced design study, economic assessment, recommendations and final report). Practical results of the study have already been applied in several key areas such as the planning of information and control systems and of terminal expansion measures).

A survey of the technology for truck, rail, marine and air-freight terminals identified at least ten different categories of transfer and storage equipment. These ranged from conventional toplifters to fully-automated terminals and even automated high-rise container warehouses. Visits were made to some twenty-five installations in Canada, eastern U.S.A., Great Britain, Holland, and West Germany. Due account was also taken of other research programs in North America and Europe. In particular, those by F.R.A. Washington, CN Rail, British Rail Freightliners, British National Ports Council, and West German railroads and ports.

Over the next ten years, dramatic changes are predicted in the operating environment of intermodal terminals, for example business volume, traffic patterns, railway operations, intermodal equipment.

Innovative freight systems are being developed which are more specific to intermodal's needs. Examples include the "Domestic Container" system by CP Rail, the "Ten-Pack" light-weight articulated railcar by Sante Fe, the "Double-Stack" container car by Southern Pacific, and "Sprint" train service for intercity corridors. Some of these systems are designed to optimise linehaul operations first, and corresponding changes may be required in terminal and truck operations. This report does not deal with these developments.

In order to support the high levels of growth predicted in intermodal freight, long-range assumptions must be developed. These should be based on a thorough market analysis which goes beyond the view of short-term business cycles. The capital investment required to implement these changes demands:

1- a flexible approach to implementation because of the revenue cycles are tied to the varying traffic cycles;

2- a long-range view in order to be ready should the traffic growth outstrip the capacity of the present facilities and procedures to deliver.

3. TERMINAL CAPACITY

The objective of the study was to determine the optimal allocation of terminal area to track, storage, roadways, inspection areas and transfer areas. In order to achieve the objectives, a five year traffic forecast was developed and, using peak figures, the operation of a terminal was simulated for one day. The results of the simulation provided the basis for making recommendations concerning operating policy. The data was also used for investigating various terminal layouts as described in Appendix III, Cost Model.

3.1 Traffic Forecast to 1984

The traffic forecast illustrated in Table 1.1 for trailers, domestic containers and marine containers constitutes the basis of capacity requirements.

Table 1.1 Projected Intermodal Terminal Handlings - All Plans

	1980	1981	1982	1983	1984
Trailers	82,958	82,120	79,786	74,456	72,528
Domestic Containers	4,500	17,400	32,000	50,000	66,000
Marine Containers	65,757	69,045	71,116	73,250	75,447

This estimate in traffic growth was based upon the traffic moving between various origin-destination pairs in 1979. The growth in Plan II traffic in trailers in 1979 has been divided into domestic containers and Plan II trailer traffic.

A more precise breakdown of the 1984 forecasted handlings for a peak week can be found in Table 1.2. This table presents the anticipated volume of trailers, domestic containers and marine containers to be received and forwarded during a seven day period. These figures provided the basis for the simulation which will be described in a later section.

3.2 Cycle Times for Handling Equipment

The cycle times for the different handling equipment within the terminal were established over a two-day period. These times were recorded for comparison purposes only since the cycle times for the manual simulation were determined from the operating experience of the terminal personnel.

Table 1.2 Intermodal Handlings - 1984 Peak Months

	Received By Rail								Forwarded By Rail						
	Trailers				Containers				Trailers			Containers			
Day of the Week	Plan I-III	Plan II		Total	Plan II		Domestic Total	Marine Import (1)	Plan I-III	Plan II	Total	Plan II Domestic	Plan II Marine	Marine Export	Total Marine
	LD	LD	MT		LD	MT(5)									
Sunday	83	27	27	137	62	67	129	200	0	0	0	0	0	0	0
Monday	45	19	30	94	38	62	100	56	106	56	162	124	21	75	96
Tuesday	60	22	27	109	51	60	111	56	119	65	184	138	22	189	211
Wednesday	83	31	22	136	64	39	103	56	119	65	184	138	22	128	150
Thursday	80	29	16	125	58	30	88	56	119	66	185	138	22	155	177
Friday	91	24	22	137	52	47	99	200	125	69	194	147	24	108	132
Saturday	100	34	30	164	73	66	139	56	73	39	112	84	15	20	35
Total	542	186	174	902	398	371	769	680(3)	661	360	1,021	769	126	675 (4)	801

(1) This estimate is based upon the 80th percentile of the containers received, pro-rated to 1984 traffic levels, arriving on the two days on which the peak is likely to occur. The remaining traffic is allocated over the other 5 days.

(2) This estimate is based upon the relating percentage of the week's traffic forwarded each day in descending order of daily volumes to probability that the peak will occur on a given day in the week.

(3) 680 handlings = 884 TEU; 476 - 20 foot and 204 - 40 foot

(4) 675 handlings = 877 TEU; 473 - 20 foot and 202 - 40 foot

(5) MT = Empty container or trailer

The cycle time for ramping is defined as the time interval from the time a tractor and/or tractor-trailer crosses the ramp onto a flat car, to the time it crosses the ramp in the opposite direction. This cycle time is a function of the number of cars to be traversed between the ramp and the car being loaded or unloaded. The total cycle time for 15 cars, excluding delays in unloading, was 34.35 minutes. The ground cycle time, the time between crossing the ramp, parking the trailer and returning to the ramp, was an average 3.3 minutes per trailer for unloading and 3.15 minutes per trailer for loading during peak loading and unloading periods. These times do not take into account delays, coffee breaks, and allowances for break-downs.

For the toplifters, 13.5 percent of an 8 hour shift was recorded for the driver's personal time. The time spent lifting containers, running light and storing containers is a function of the distance between points on the different tracks and in the storage areas. The average cycle time per handling was 2.17 minutes for containers placed in areas A, B or C but increased to 3.08 minutes for the remote on-site storage area. Running light from one area to another between handlings accounted for 35.6 percent of the time the toplifters were used. Figure 1.2 shows the present layout of Terminal 'X'.

The cycle time for cranes had to be determined from sources outside the terminal since no cranes are used. These sources included CN Rail, manufacturer's back-up information and the A.T. Kearney Inc. Report to the F.R.A. The average cycle time for cranes, taking into account the different models used in intermodal terminals, in 1.8 minutes to load or unload a unit from a flat-car to the ground or a chassis.

Comparing the cycle times of the different handling equipment, cranes are the most efficient means of loading and unloading but are less flexible than toplifters. Circus ramping is both time and space inefficient.

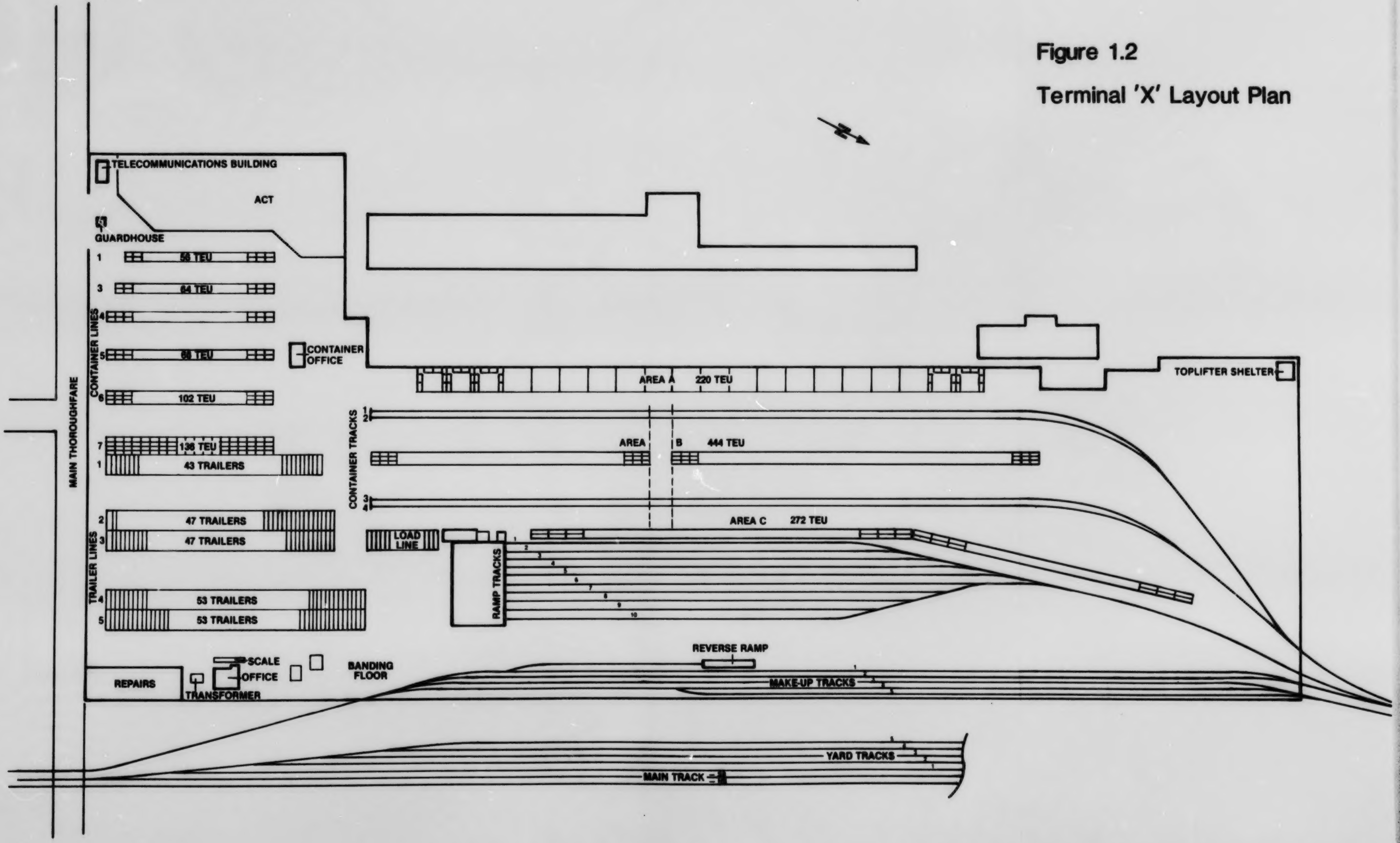

TELECOMMUNICATIONS BUILDING
ACT
GUARDHOUSE
MAIN THOROUGHFARE
CONTAINER LINES
1
56 TEU
3
64 TEU
4
5
68 TEU
CONTAINER OFFICE
6
102 TEU
7
136 TEU
1
43 TRAILERS
TRAILER LINES
2
47 TRAILERS
3
47 TRAILERS
4
53 TRAILERS
5
53 TRAILERS
CONTAINER TRACKS
1
2
3
4
AREA A
220 TEU
AREA
B
444 TEU
AREA C
272 TEU
TOPLIFTER SHELTER
N
LOAD LINE
RAMP TRACKS
1
2
3
4
5
6
7
8
9
10
REVERSE RAMP
MAKE-UP TRACKS
1
2
3
4
5
REPAIRS
TRANSFORMER
SCALE
OFFICE
BANDING FLOOR
YARD TRACKS
5
4
3
2
1
MAIN TRACK

Figure 1.2

Terminal 'X' Layout Plan

3.3 Gate Activity

The security gate, including the inspection stations and the weigh scales, is the point through which any highway traffic, either in or out, has to pass. During the study week, a record was kept showing trailers and containers entering and leaving the terminal.

The peak period for trailer arrivals was from 1500 hours to 1800 hours, at a rate of up to 32 per hour. Containers and container chassis arrived uniformly during the day from 0900 hours to 1900 hours at a rate of 10 to 13 an hour. Bob-tail tractors, used to haul away trailers and containers on chassis, usually arrived from 0600 to 1000 hours.

The gate exit record for the study period shows that the majority of loaded trailers leave the terminal from 0700 to 1200 hours. The requirement for empty trailers is uniform during the day. Loaded and empty containers left through the gate uniformly over the period between 0700 and 1800 hours.

The figures compiled from the gate study were used to determine the traffic for an average day. These averages yielded projected daily arrival and departure distributions which were used during the manual simulations.

3.4 Track and Storage Requirements

The ground storage requirements for trailers and containers were determined by manual simulation and by recording the inventory of trailers and containers on hand for the next day at the end of each day's activity. The total ground storage area required must provide enough space for grounding trailers and containers arriving on a given day.

The track length requirements were calculated as a function of daily peak handlings and car lengths. It was assumed that one trailer was loaded on a 57 foot 7 inch flat car and that two domestic containers fit onto a 94 foot 8 inch car. Marine containers were loaded on two types of flat cars, either 49 feet 4 inches long or 86 feet 7 inches long, on a ratio of 40:60. The requirements for 1984 levels of traffic were determined using the traffic figures forecast and the results of the manual simulation.

Table 1.3 summarizes both the storage and track requirements for the different levels of traffic.

Table 1.3 Terminal Handlings - Peak Months 1980 - 1984

Trailers

	1980	1981	1982	1983	1984	
Annual handlings	82,958	82,120	79,786	74,456	72,528	
Peak day	222	220	213	199	194	(1)
Track length (feet)	12,784	12,668	12,265	11,459	11,171	(2)
Storage (units)	383	379	369	344	335	(3)

(1) Friday trailers forwarded by rail
(2) 194 rail cars @ 57 feet 7 inches
(3) Sunday midnight, includes 57 empty Plan II trailers

Domestics

	1980	1981	1982	1983	1984	
Annual handlings	4,500	17,400	32,000	50,000	66,000	
Peak day	10	39	71	111	147	(1)
Track length (feet)	474	1,894	3,408	5,301	7,005	(2)
Storage (units)-loads	11	43	80	124	164	
-empties	9	35	64	101	133	
-empty chassis	3	13	24	38	50	(3)
-Total	23	91	168	263	347	(4)

(1) Friday domestic containers forwarded by rail
(2) 147 containers require 74 cars @ 94 feet 8 inches
(3) These estimates are very rough because there is little experience upon which to base an analysis
(4) Sunday midnight, includes 133 empties

Marine

	1980	1981	1982	1983	1984	
Annual handlings	65,757	69,045	71,116	73,250	75,447	
Peak day	200	200	200	205	211	(1)
Track length	6,130	6,130	6,130	6,283	6,467	(2)
Storage (TEU)	1,055	1,107	1,141	1,175	1,210	(3)
Loaded empty storage (TEU)	1,120	1,175	1,211	1,247	1,285	(4)

(1) Tuesday marine containers forwarded by rail (includes Plan II marine)
(2) See equation in Table 2.19, Appendix I
(3) Sunday midnight
(4) All empties assumed to be stored off-site

3.5 Short-Term Recommendations

The present trackage available within the terminal studied consists of:

- 4 container tracks with a total of 6,300 feet
- 10 piggyback tracks with 10,538 feet
- 5 make-up tracks with a total holding capacity of 146-55 foot cars
- 1 reverse ramp track with a holding capacity of 7-55 foot cars

These tracks are adequate for containers but will not be enough for the 1984 levels of traffic forecast (72,528 trailers out of the total traffic of 214,000 units per year).

Temporary recommendations to alleviate this problem are:

- changes in operating practices;
- increases in the efficiency of switching;
- trackage expansion.

The trackage expansion suggested is illustrated in Figure 1.3. Two ramp tracks and the reverse ramp have been removed, and two new tracks (9 & 10) run along the make-up tracks. Track one now runs from the container lead and allows the use of toplifters and piggypackers on this track. Track eight can now also be loaded and unloaded by piggypackers and toplifters.

These recommendations may alleviate some of the capacity problem at the 200,000 unit level, however, the cost model (appendix III) reviews in greater detail the recommended modifications to the existing facilities which will apply to levels of up to 400,000 units per year.

3.6 Manual Simulation

In order to study the effect of limited track layout options and operating procedures, a computer-assisted simulation model was not found necessary. Since only one terminal was studied and a simulation of only one day was performed, a manual simulation technique was considered to be adequate. (Information concerning computer-assisted simulation techniques can be found in Annexes I, II and III of Appendix I).

A scaled plan of the terminal under study (Figure 1.2) was drawn on a magnetic board and cards were cut to scale to represent rail cars, trailers and containers. The manual simulation was made from January 12 to January 15, 1981, and the day's activities were simulated in detail on an hour by hour basis with records kept of the activities of:

- road engines;
- yard engines;
- ramp tractors;
- piggypackers;
- toplifters.

The individual participants, members of the terminal operating staff, were responsible for monitoring the activities relating to their normal work at the terminal.

In general, the results of the simulation show that the throughput activity of the terminal for arrivals is adequate. There is enough "slack" time to handle late arrivals although at a lower service level. The problems encountered related to the traffic forwarded by rail due to cut-off times and track configurations. Storage was not a problem, however, the day simulated is not a peak storage day.

The revised terminal (Figure 1.3) is a partial conversion from ramps to toplifters and piggypackers for trailers. Track 7, through track with access to both the north and south yard tracks, has the added flexibility that it can hold a mix of trailer flat cars and container flat cars which can be assembled into any blocks needed to complete a train.

An ideal terminal would, however, phase-out the ramps completely which would allow faster handling equipment to load and unload the units and afford greater storage area utilization, especially if the tracks could be turned over more than once a day. The Cost Model presented in Appendix III outlines different track layout and storage options along with the associated capital and operating costs.

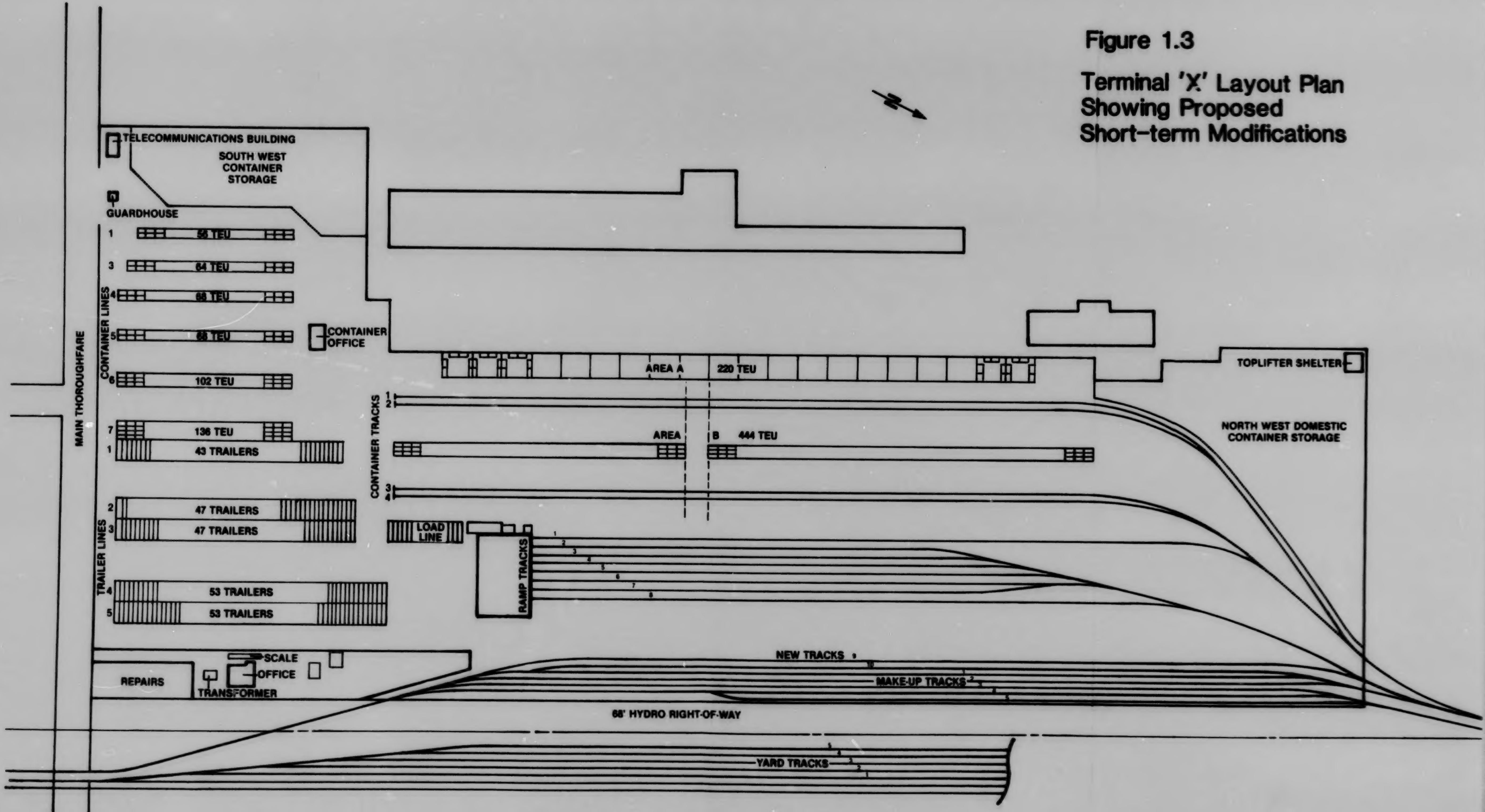

TELECOMMUNICATIONS BUILDING
SOUTH WEST CONTAINER STORAGE
GUARDHOUSE
CONTAINER LINES
1
56 TEU
3
64 TEU
4
68 TEU
5
68 TEU
6
102 TEU
7
136 TEU
CONTAINER OFFICE
MAIN THOROUGHFARE
TRAILER LINES
1
43 TRAILERS
2
47 TRAILERS
3
47 TRAILERS
4
53 TRAILERS
5
53 TRAILERS
LOAD LINE
RAMP TRACKS
1
2
3
4
5
6
7
8
CONTAINER TRACKS
1
2
3
4
AREA A
220 TEU
AREA
B
444 TEU
TOPLIFTER SHELTER
NORTH WEST DOMESTIC CONTAINER STORAGE
NEW TRACKS
9
10
MAKE-UP TRACKS
1
2
3
4
5
REPAIRS
SCALE
OFFICE
TRANSFORMER
68' HYDRO RIGHT-OF-WAY
YARD TRACKS
5
4
3
2
1
N

Figure 1.3

Terminal 'X' Layout Plan Showing Proposed Short-term Modifications

4. TERMINAL MANAGEMENT SYSTEM

The primary purpose of a terminal management system (TMS) is to report upon the different traffic flows and assist in their control. Sufficient information must be provided on a timely basis so that the personnel involved in the control of the terminal can decide on the most effective means of handling the loads and equipment within the terminal and can coordinate with the linehaul system and the shippers, consignees and contractors.

The terminal management system also provides the data needed for the reporting of revenue and expenses and for assessing terminal efficiency.

The computer support required for the TMS should take into account four main areas;

1- the equipment inventory;
2- the road interface;
3- the rail interface;
4- communications.

The following four sections will describe these aspects and their operating characteristics.

4.1 The Equipment Inventory

This facility will track and report the movement of all intermodal equipment within the control of the terminal. The terminal is responsible for trailers, containers, chassis and railcars within its area. It must control their status (loaded, empty, bad order) and their location (on delivery, awaiting loading, enroute by rail).

The proposed equipment inventory system would allow the following:

- record the data relevant to the interchange of trailers and containers from the yard to either the road through the inspection gate or the rail system.
- track the location of all equipment for which the terminal is responsible.
- track the status and service availability of each item within the inventory.
- allocate parking locations for trailers and containers.
- provide entry/exit information in order to assist in the creation or in the termination of waybills.

- compile historical data and statistics of day-to-day information for reporting purposes;
- record the information required to control the release of intermodal units from the terminal;
- calculate and record charges associated with the storage of units not owned by the railroad;
- calculate and record the charges for the rental of containers and trailers.

4.2 The Road Interface

The road interface will handle the transition of units between the road and the yard. The main point of control for this task is the inspection and scale gates. It is from this point that the information relevant to the entry of trailers, containers and chassis from the road into the terminal, and their release to consignees, is gathered.

Within the terminal administration office, the dispatcher will also be concerned with this information since it is his task to coordinate the movement of all deliveries and to release empty units to the shippers.

The road interface feature of the terminal management system will control the following:

- record the demand from shippers for empty units.
- assist in the forecasting of the dispatcher's workload and his fleet requirements.
- allow for the dispatching of units according to priority if required.
- record the assignment of fleet tractors.

4.3 The Rail Interface

The rail interface will handle the information needed to control the transition of trailers and containers between the yard and the rail system. This system should be closely linked to the railroad fleet tracking system so that the interchange of information concerning train arrivals and departures can benefit both the terminal staff and linehaul staff.

This feature would allow a better control of:

- the coordination of train stripping and loading;
- a more efficient train make-up;
- the planning of rail car usage at the terminal, region or system level.

4.4 Communication

Terminal staff within the yard is highly mobile, yet the information available within the computer system should be accessible so they may better coordinate their activities. They should also be able to contribute information to the system. The section on implementation will outline the suggested equipment that can link the yard personnel with the overall system.

4.5 Interchange Between TMS and Other Systems

Many information management systems are either on-line or in the planning stages to better control different aspects of railroad operations and services. These include waybilling, vouchering, fleet tracking and the compilation of statistics for corporate reporting purposes.

This section will outline two major systems, waybilling and the railway fleet tracking and how they must interface with TMS to achieve an integrated whole useful to all concerned.

4.5.1 Waybilling

The waybilling system keeps an up-to-date base of information concerning shipments, their weights, content, destination and charges. A waybill for intermodal shipments is created when the unit enters the terminal. Copies are sent with the train conductor and terminated when the shipment arrives at destination.

The TMS, through its road interface module, would provide the unit number, weight and bill of lading for the creation of the waybill.

Exit of the unit through the destination inspection gate would terminate the waybill which can then be sent to revenue for collection. Waybilling could also provide the credit information which would allow the inspection gate staff to collect the fees before releasing the unit when necessary.

4.5.2 Railway Fleet Tracking System

This system monitors the location and status of each unit of rolling stock within the rail system.

Through integration with TMS and waybilling a unit (container or trailer) number can be cross-referenced with its waybill number and the flat car number on which it is loaded. With the information any form of inquiry can easily be accessed to assist in customer inquiries, terminal management of incoming trains for stuffing and update the inventory information about available rail cars or empty trailers and containers.

4.6 Implementation

The aim of the proposed TMS is to convert today's forms and handwritten lists to a computer system. In order to achieve maximum benefit from the implementation of this system, it should be done in manageable steps as an integral part of the expansion of facilities with progressive evaluation of the features by the personnel involved with using it.

The first feature required is the inventory tracking system. This system would allow the recording of relevant information concerning equipment permanently or temporarily within the control of the terminal. The processing of this information would also permit the compilation of statistics and other historical record that would allow better coordination of equipment utilization.

The inventory tracking module could also cross-reference its information with the waybilling and railway fleet tracking system to allow a smoother transition from one mode to another.

The second set of features to be implemented should support basic reporting of the activities relevant to the road and rail interfaces as described in section 2.2 and 2.3.

As traffic increases within the terminal and operating procedures are examined and improved, added computer support modules should be implemented to make decisions according to known criteria. For example a system can be devised to allocate specific trailer parking slots taking into account expected loading time, yard configuration or whether it is a reefer or other unit requiring special attention.

4.6.1 Computer Equipment

The basic hardware support required within the terminal offices is an on-line terminal with a VDU within the dispatchers office, and one for the inspection gate. As traffic increases, additional units would be needed in larger terminals taking into account the operating procedures within the administration office.

At a later date, mobile terminals can be installed in the toplifter or cranes to better control their activities and allow up--to-date information to be entered in the computer.

These terminals should be connected to a larger central processing unit with access to the other rail and revenue control systems.

5. THE COST MODEL

The cost analysis of an existing terminal and different expansion options was performed. A terminal was expanded from 100,000 handlings a year to a maximum level of 400,000 handlings a year with an equally split traffic mix of one-third marine containers, one-third domestic containers, and one-third trailers. All costs were evaluated based on 1981 operating costs and capital expenditures.

5.1 General Terminal Configurations

Terminal configurations are determined by such factors as area, its geometry, the operating techniques and handling equipment. There can, therefore, be no "perfect" configuration for a given annual throughput. Certain design parameters such as location of storage must be considered in conceiving a terminal. Annexes 4.1 and 4.2 of Appendix III present detailed parameters to be considered which take into account the working area, hostling needs and handling equipment speeds.

5.2 Physical Requirements for Conceptual Terminals

The design requirements for the seven basic cases considered were evaluated according to certain factors that allow the determination of the requirements at certain capacities. Table 1.4 outlines the different factors used in the calculation of track length and storage requirements.

Table 1.4 Trackage and Storage Design Factors

	Annual	Trackage @ 1.0 Turns/Day		Storage	
Service	Volume	Required	Factor	Required	Factor
	(units)	(feet)	(per annual volume unit)		(per annual volume unit)
Trailers	72,528	11,171	0.154 ft.	335 units	0.0046 units
Domestic Containers	66,000	7,005	0.106 ft.		
- loaded				164 units	0.0025 units
- empty				133 units	0.0020 units
- chassis				50 units	0.00075 units
Marine Containers	75,447	6,467	0.086 ft.		
- loaded				1,210 TEU	0.0160 TEU
- empty				1,285 TEU	0.0170 TEU

The options studied for the expansion of Terminal 'X' from a 100,000-unit per year handling capacity to a 400,000-unit capacity are designated as Cases A, B1, B2, C1, C2, C3 and C4. Case A is based upon the existing 50-acre terminal using conventional handling technology and storage within the yard. Cases B1 and B2 show how the introduction of piggypackers combined with the removal of the existing piggyback ramps allows the terminal throughout to increase to 200,000 units per year without having to use a remote off-site location for containers. These cases should be compared to the present configuration of Terminal 'X' which uses conventional ramps and requires an off-site storage area at only 150,000 units per year. Cases C1 and C2 both involve the increase of handling capacity to 400,000 units per year within the same land area as Cases B1 and B2 with additional storage being provided at an off-site location. These 2 cases show how the capacity of the terminal can be pushed to the limit. Cases C3 and C4 involve the construction of a new terminal on a new site with the attendant savings in shuttling and switching.

Applying the constants developed in Table 1.4 to the throughput assumptions for the cases under consideration gives the physical requirements for trackage and storage as follows:

Table 1.5 Storage and Trackage Requirements - All Cases

	Case A	Cases B1, B2	Cases C1, C2, C3, C4
Annual Throughput (units)			
Total	100,000	200,000	400,000
Trailers	33,333	66,667	133,333
Domestic Containers	33,333	66,667	133,333
Marine Containers	33,333	66,667	133,333
Trackage Requirements at 1.0 Turns per Day (lineal feet)			
Trailers	5,133	10,267	20,533
Domestic Containers	3,533	7,067	14,133
Marine Containers	2,867	5,733	11,467
Storage Requirements			
Trailers (units)	153	307	613
Domestic Containers (units)			
- Loaded	83	167	333
- Empty	67	133	267
- Chassis	25	50	100
Marine Containers (TEU)			
- Loaded	533	1,067	2,133
- Empty	567	1,133	2,267

It should be noted that these requirements are based upon the arrival and departure patterns at Terminal 'X' and as such may not be valid for other intermodal terminals. When evaluating other terminals, the factors presented in Table 1.4 should be determined before calculating the trackage and space requirements for any expansion cases being considered.

Table 1.6 Track Length, Storage and Handling Equipment - All Cases

	Case A	Case B1	Case B2	Case C1	Case C2	Case C3	Case C4
Track Length							
Required	11,533	23,067	23,067	46,133	46,133	46,133	46,133
Available	11,200	11,590	15,810	12,140	28,020	23,068	23,068
Turns per day	1.0	2.0	1.5	3.8	1.6	2.0	2.0
Storage Available							
Marine							
- Loaded	533	1,110	1,117	2,133	2,133	2,271	2,131
- Empty	578	1,143	1,143	2,267	2,267	2,267	2,267
Domestic							
- Loaded	85	267	233	331	333	333	333
- Empty	72	141	150	267	267	267	267
- Chassis	25	35	35	100	100	100	100
Trailers	153	273	260	634	198	613	613
Handling Equipment							
- Toplifters	4	9	9	9	6	9	12
- Piggypackers	-	3	3	4	-	4	4
- Cranes	-	-	-	(060)9	(030)12	(060)9	-

The handling equipment requirements were determined from the peak working capacities presented in Table 4.4 and the peak daily handling requirement factors presented in Table 4.5 (both in Appendix III). In determining these requirements, an additional 20 percent was used in order to provide additional units for maintenance.

5.3 Terminal Configurations

The options studied for the expansion of Terminal 'X', the existing terminal, from 100,000 units per year to a capacity of 400,000 units per year are designated as Cases A, B1, B2, C1, C2, C3, and C4. The following sections describe each case and the conclusions reached as a result of the analysis of the options available. A summary of the physical characteristics designed for these cases is presented below.

Labour							
					18	13	13
- Hostler Drivers	5	7	8	15	20	-	-
- Shuttlers	-	-	-	5	29	25	22
- Machine Operators	7	19	19	31			

5.3.1 Case A

The design of the present terminal is based upon the stub-track concept in which ramps are used to handle trailers and toplifters to handle marine and domestic containers. The rail equipment (container and trailer flat cars) is segregated at the marshalling yards and shuttled into the terminal. Access to the terminal is through a single entry lead track which serves for both the entry and exit of railway line-haul equipment. The flat cars with trailers are placed on the ramp tracks. Hostlers then drive up the ramps and pull the trailers off the flat cars into the storage area in sequence, (first in, last out). Containers on flat cars are switched into the terminal to the container tracks using the same lead track where toplifters remove them from the flat cars and stack them for storage or place them on chassis for delivery. All storage of trailers and containers is provided for on-site thus eliminating the need and cost of shuttling. Loaded containers are stacked 2 X 2 while empty containers are block stacked only 2 high because there is ample space available at the existing site. Figure 1.4 shows the layout for Case A.

At 100,000 units per year, the existing facilities are more than adequate to handle the traffic without requiring the use of the remote off-site storage area. The remote on-site area will probably be used for the storage of trailers since it is easier to hostle them off the ramp and into this area than to turn around and drive along the ramp tracks.

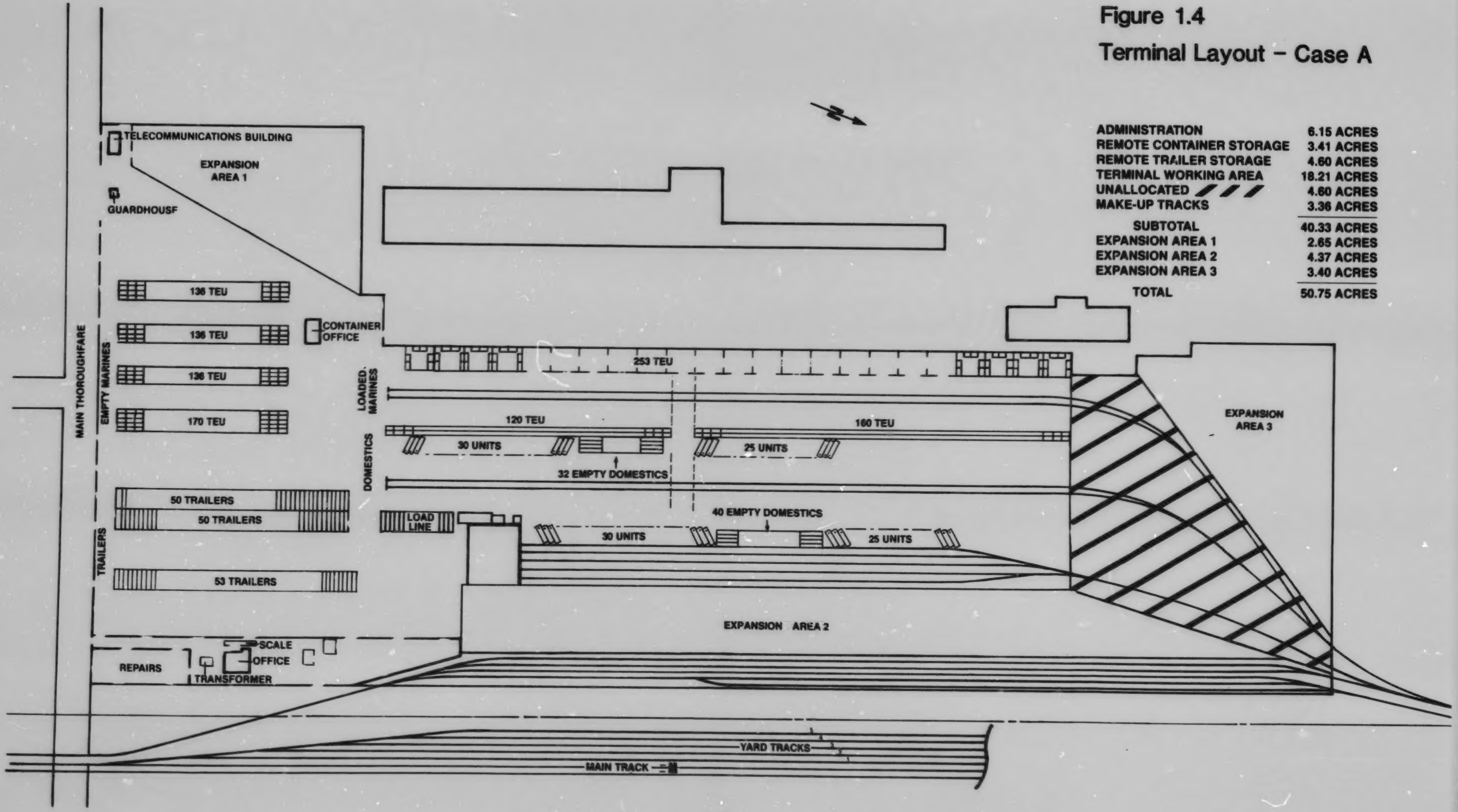

TELECOMMUNICATIONS BUILDING
EXPANSION AREA 1
GUARDHOUSE
136 TEU
136 TEU
136 TEU
170 TEU
CONTAINER OFFICE
MAIN THOROUGHFARE
EMPTY MARINES
LOADED MARINES
DOMESTICS
253 TEU
120 TEU
160 TEU
30 UNITS
25 UNITS
32 EMPTY DOMESTICS
40 EMPTY DOMESTICS
30 UNITS
25 UNITS
50 TRAILERS
50 TRAILERS
LOAD LINE
TRAILERS
53 TRAILERS
EXPANSION AREA 3
EXPANSION AREA 2
SCALE
OFFICE
REPAIRS
TRANSFORMER
YARD TRACKS
MAIN TRACK
N

Figure 1.4

Terminal Layout - Case A

ADMINISTRATION	6.15 ACRES
REMOTE CONTAINER STORAGE	3.41 ACRES
REMOTE TRAILER STORAGE	4.60 ACRES
TERMINAL WORKING AREA	18.21 ACRES
UNALLOCATED ▨	4.60 ACRES
MAKE-UP TRACKS	3.36 ACRES
SUBTOTAL	40.33 ACRES
EXPANSION AREA 1	2.65 ACRES
EXPANSION AREA 2	4.37 ACRES
EXPANSION AREA 3	3.40 ACRES
TOTAL	50.75 ACRES

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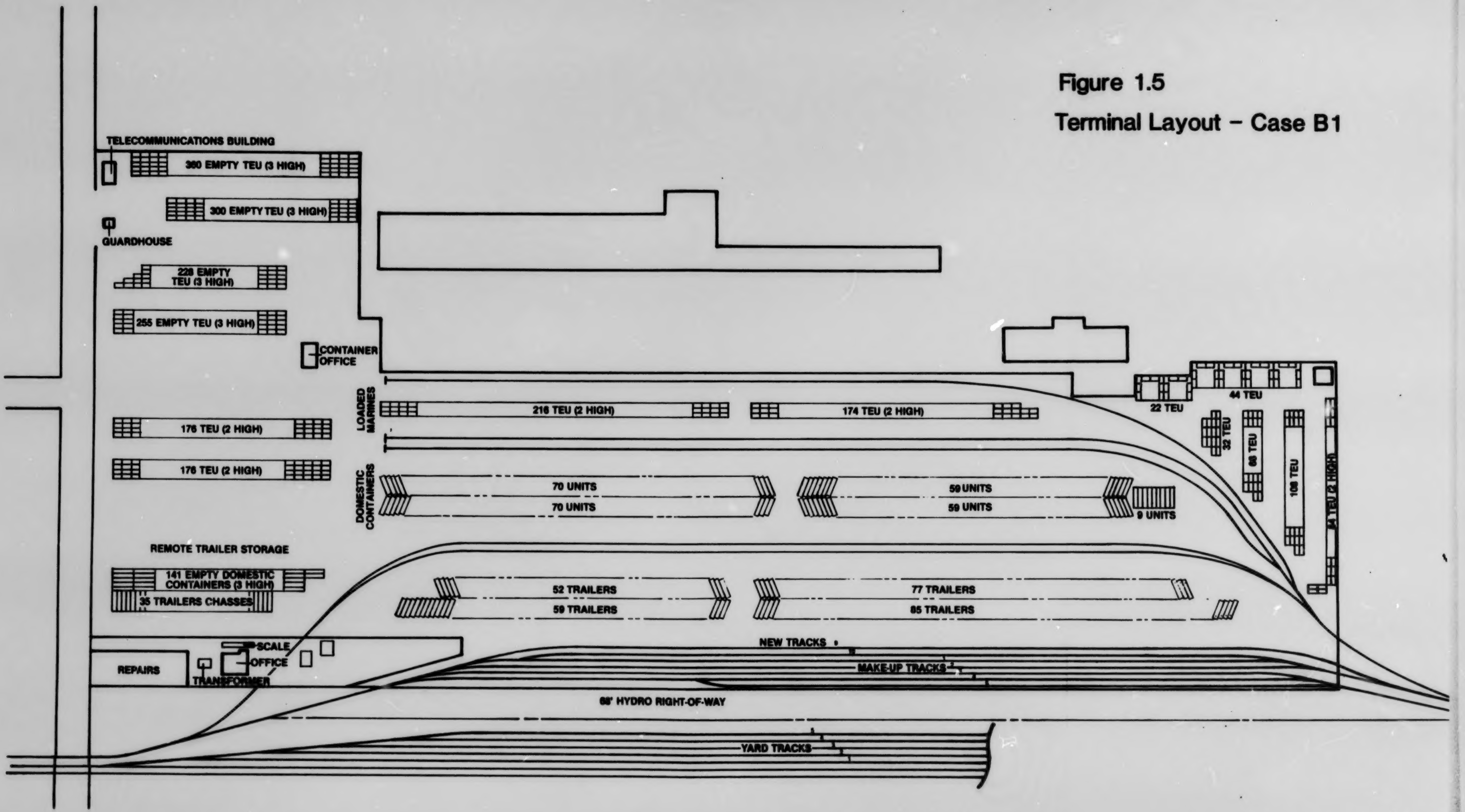
5.3.2 Case B1

This case assumes that the expansion of Terminal 'X' to handle an annual throughput of 200,000 units per year is made by converting it to an integral terminal with no off-site storage. This conversion is accomplished by removing the piggyback ramp and replacing the circus loading of trailers with side transferring using piggypackers. In this case empty containers are stored 3 high using piggypackers. Empty containers are stored 3 high in order to increase the density of the block storage piles. The total length of track in the yard is reduced dramatically because of the removal of the ramp tracks which requires the yard engine to turn the tracks more frequently. The greatest amount of ground storage is located in the working area between the tracks. One possible layout is presented in Figure 1.5.

From the physical requirements presented in (Table 1.6), several important features become apparent. The total storage requirements can be handled easily, although some of the trailers and domestic container chassis may have to be stored in the Hydro right-of-way during certain peak hours. The track utilization must also increase dramatically from Case A. This increase should present the yard engine crews little problem because the number of tracks to be switched has been reduced from 13 (present Terminal 'X') to 6 and there is sufficient external storage with which to hold the entire complement of cars on the peak day (27,932 feet). Additionally, the provision of an access from the south to Trailer 1 and 2 and to Container track 1 will help to reduce switching delays when the road engines are switching the yard tracks. The fact that a larger part of the ground storage is located in the working area means that hostling costs should be reduced. Also, since there is no requirement for remote off-site storage, there will be no shuttling costs.

Figure 1.5

Terminal Layout - Case B1


TELECOMMUNICATIONS BUILDING
360 EMPTY TEU (3 HIGH)
300 EMPTY TEU (3 HIGH)
GUARDHOUSE
228 EMPTY TEU (3 HIGH)
255 EMPTY TEU (3 HIGH)
CONTAINER OFFICE
LOADED MARINES
216 TEU (2 HIGH)
174 TEU (2 HIGH)
22 TEU
44 TEU
32 TEU
88 TEU
108 TEU
84 TEU (2 HIGH)
176 TEU (2 HIGH)
176 TEU (2 HIGH)
DOMESTIC CONTAINERS
70 UNITS
70 UNITS
59 UNITS
59 UNITS
9 UNITS
REMOTE TRAILER STORAGE
141 EMPTY DOMESTIC CONTAINERS (3 HIGH)
35 TRAILERS CHASSES
52 TRAILERS
59 TRAILERS
77 TRAILERS
85 TRAILERS
SCALE
OFFICE
REPAIRS
TRANSFORMER
NEW TRACKS
MAKE-UP TRACKS
66' HYDRO RIGHT-OF-WAY
YARD TRACKS

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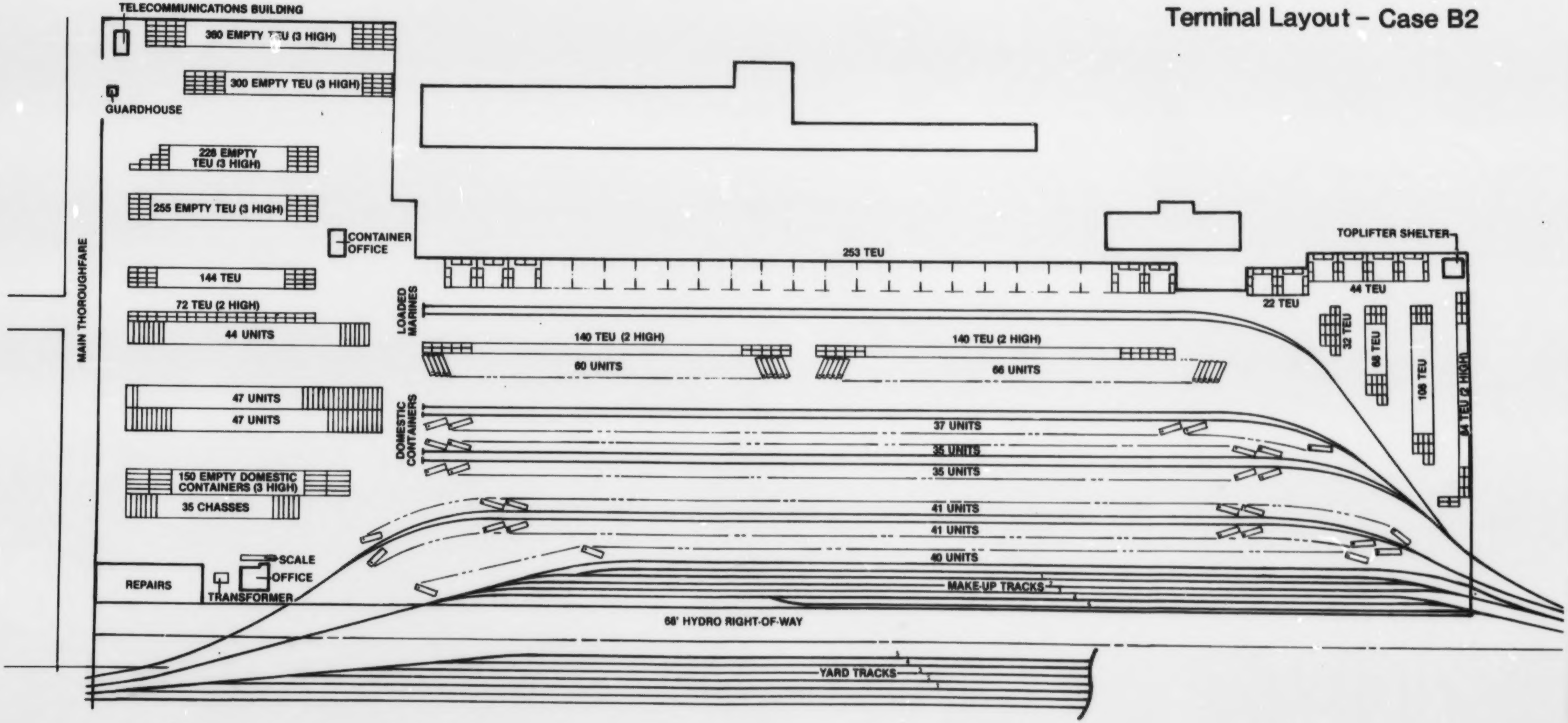
5.3.3 Case B2

This case is also designed to show how Terminal 'X' can be expanded to handle 200,000 units per year by converting part of it to a transfer terminal with very little ground storage being provided in the working area. The trailer ramps are again replaced with long tracks being handled with piggypackers, however, more remote on-site storage is required. Figure 1.6 illustrates the configuration examined in this case.

The basic advantage that Case B1 has over Case B2 is that there is more storage area available in the working area in Case B1 which reduces the amount of on-site hostling required. In order to gain this advantage, however, the tracks must be turned more frequently in Case B1 because of the reduced trackage on-site.

Figure 1.6

Terminal Layout - Case B2


TELECOMMUNICATIONS BUILDING
360 EMPTY TEU (3 HIGH)
300 EMPTY TEU (3 HIGH)
GUARDHOUSE
228 EMPTY TEU (3 HIGH)
255 EMPTY TEU (3 HIGH)
CONTAINER OFFICE
144 TEU
72 TEU (2 HIGH)
44 UNITS
MAIN THOROUGHFARE
47 UNITS
47 UNITS
150 EMPTY DOMESTIC CONTAINERS (3 HIGH)
35 CHASSES
REPAIRS
SCALE
OFFICE
TRANSFORMER
253 TEU
TOPLIFTER SHELTER
22 TEU
44 TEU
32 TEU
68 TEU
108 TEU
84 TEU (2 HIGH)
LOADED MARINES
140 TEU (2 HIGH)
60 UNITS
140 TEU (2 HIGH)
66 UNITS
DOMESTIC CONTAINERS
37 UNITS
35 UNITS
35 UNITS
41 UNITS
41 UNITS
40 UNITS
MAKE-UP TRACKS
68' HYDRO RIGHT-OF-WAY
YARD TRACKS

5.3.4 Conclusions Regarding Cases B1 and B2

Both of these cases will require an improved level of up-to-date location information so that the loading operations during the evening and nighttime hours can be destination segregated, i.e. long blocks of single destination traffic must be loaded at one time because the yard engine will not have enough time to marshall sets of cars in the make-up and yard tracks. Appendix II discusses these information systems requirements in greater detail.

It is interesting to note that the advent of piggypackers for the handling of trailers has created the ability to design yard layouts which are much more space efficient. Regardless of the design concepts instituted (transfer terminal or integral terminal), the removal of the traditional circus loading tracks and ramps and the subsequent increase in track turnaround allows more on-site storage. In the case of Terminal 'X', the traditional layout requires an off-site remote storage area for the empty marine containers at an annual throughput of 150,000 units. By converting to a piggypacker operation, the same terminal can handle 200,000 units per year without requiring an off-site remote storage area.

5.3.5 Case C1

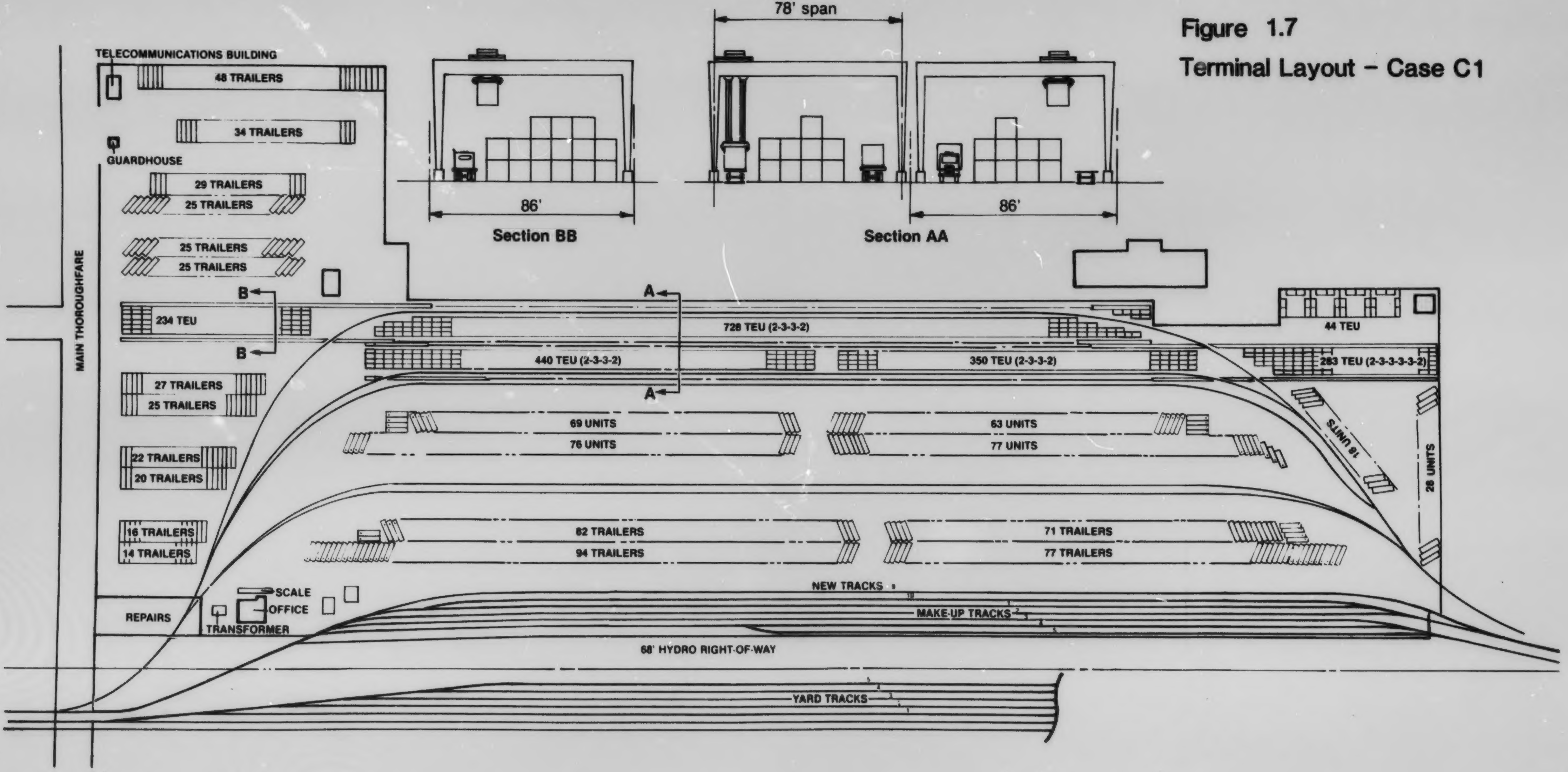
This case shows the logical expansion of the layout designated as Case B1 from 200,000 units per year to 400,000 units per year. This expansion takes place on the existing site by increasing the density of the marine container handling facilities and by moving the storage of empty marine and domestic containers to a remote off-site location. The increase in density of the marine container handling facilities is accomplished by replacing the toplifters with long span 060 cranes. The terminal layout for Case C1 is presented in Figure 1.7. Although not shown in Figure 1.7, the layout assumes that the 100 domestic container chassis will be stored between the pole lines on the hydro right-of-way. This arrangement is now in effect at 'Terminal 'X' for empty trailers.

The increase in terminal throughput would be accomplished without adding further to the number of tracks. This further increase in track turnaround would be made possible by constructing a new switching lead to connect the south end of the tracks in the working area with the make-up tracks, yard tracks and the main tracks. With the volume of traffic increasing to the same number of destinations, more solid intermodal trains will be operated. The provision of a run-through capability at the terminal will allow some of the road units to assist the yard engine at the other end of the terminal tracks.

Because of the large number of switching movements crossing the main thoroughfare, this case cannot be implemented until a grade separation is built. The economic analysis presented in the next section takes the railway portion of this investment into account. The make-up and yard tracks must also be extended to provide more holding capacity for cars held off-site.

The amount of trackage external to the terminal (i.e. make-up, yard tracks and the auxiliary storage yard) becomes insufficient as the throughput approaches 400,000 units per year. Although the yard and make-up tracks can be extended slightly and the holding capacity of the auxiliary storage yard can be doubled, there is still a slight shortage of holding capacity of some 350 feet. The assumption is made in this study that some empty cars can be held for short periods of time during peak days on the main tracks or service tracks to the north of the auxilliary storage yard. (The auxiliary storage yard is not indicated on the terminal layouts).

Figure 1.7
Terminal Layout – Case C1


78' span
86'
Section BB
86'
Section AA
TELECOMMUNICATIONS BUILDING
48 TRAILERS
34 TRAILERS
GUARDHOUSE
29 TRAILERS
25 TRAILERS
25 TRAILERS
25 TRAILERS
MAIN THOROUGHFARE
B
234 TEU
B
A
728 TEU (2-3-3-2)
A
440 TEU (2-3-3-2)
350 TEU (2-3-3-2)
44 TEU
283 TEU (2-3-3-3-3-2)
27 TRAILERS
25 TRAILERS
69 UNITS
76 UNITS
63 UNITS
77 UNITS
18 UNITS
28 UNITS
22 TRAILERS
20 TRAILERS
16 TRAILERS
14 TRAILERS
82 TRAILERS
94 TRAILERS
71 TRAILERS
77 TRAILERS
NEW TRACKS
SCALE
OFFICE
REPAIRS
TRANSFORMER
MAKE-UP TRACKS
68' HYDRO RIGHT-OF-WAY
YARD TRACKS

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5.3.6 Case C2

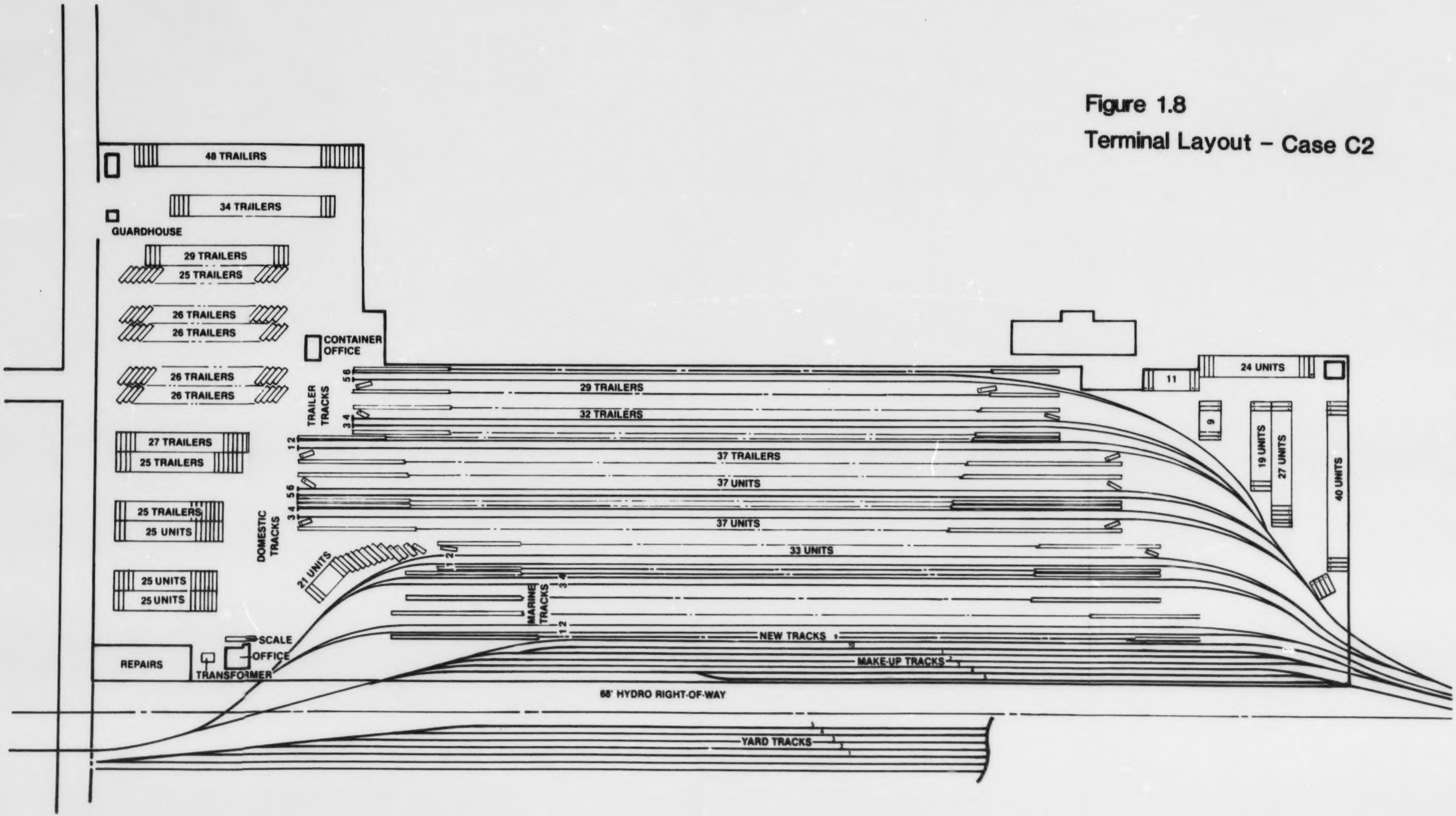
This case represents the conversion of Terminal 'X' into a transfer terminal by the installation of 030 cranes. Remote off-site storage will be provided for the empty domestic containers and all of the marine containers with remote on-site storage for most of the loaded domestic containers and chassis (some short-term storage is available in the working area). Figure 1.8 represents the layout for this case which shows the number and location of the cranes. There are no toplifters or piggypackers used at the terminal, however, they are required at the remote off-site location to handle the empty marine and domestic containers.

When in operation, the north side remote storage area will be dedicated to loaded domestic containers on chassis and the south side will be split between domestic containers on chassis and trailers. The domestic empty chassis will again be stored on the hydro right-of-way.

Because of the relatively low turnaround required for the terminal tracks, one yard engine operating 3 shifts per day should be able to handle the switching duties. The access provided to the south end of the make-up yard tracks for marine tracks 1-4 and conflicting movements which can occur when the road units are switching the make-up and yard tracks. The existing yard and make-up tracks have enough length to handle the 400,000 units without the expansion required in Case C1. Also, the grade separation at the main thoroughfare will not be required as most of the switching will be occurring at the north end of the terminal.

Figure 1.8

Terminal Layout - Case C2


48 TRAILERS
34 TRAILERS
GUARDHOUSE
29 TRAILERS
25 TRAILERS
26 TRAILERS
26 TRAILERS
26 TRAILERS
26 TRAILERS
27 TRAILERS
25 TRAILERS
25 TRAILERS
25 UNITS
25 UNITS
25 UNITS
CONTAINER OFFICE
TRAILER TRACKS
5 6
3 4
1 2
DOMESTIC TRACKS
21 UNITS
MARINE TRACKS
29 TRAILERS
32 TRAILERS
37 TRAILERS
37 UNITS
37 UNITS
33 UNITS
NEW TRACKS
MAKE-UP TRACKS
24 UNITS
11
9
19 UNITS
27 UNITS
40 UNITS
REPAIRS
TRANSFORMER
SCALE
OFFICE
68' HYDRO RIGHT-OF-WAY
YARD TRACKS

5.3.7 Shuttling to Remote Off-Site Storage

Shuttling to a remote off-site storage area is required for Cases C1 and C2 because there is insufficient land available at the main terminal. Some shuttles can be handled during the non-peak hours by the hostling tractors working in the main terminal. The balance must be handled by additional shuttle tractors.

Because each hostling tractor is not required for its entire 8 hour shift, even on peak days, there is some time available with which to assist in the shuttling operations. The daily non-peak hours are between the end of the morning rail car unloading (0900-1000 hours) until the evening railcar loadings become heavy (1600 hours). The time available to assist in the shuttling operations is limited, therefore, to the morning unloading shifts and approximately 3 hours are available per hostling tractor.

The shuttling requirements, assuming a little overtime is paid on the peak days, are 5 tractors in Case B1 and 20 tractors in Case B2.

5.3.8 Conclusions Regarding Cases C1 and C2

Again both of these cases will require a vastly improved management information system in order to operate efficiently. This requirement becomes even more apparent when one considers the fact that 2 separate areas must be controlled and coordinated rather than the single facility as in Cases B1 and B2.

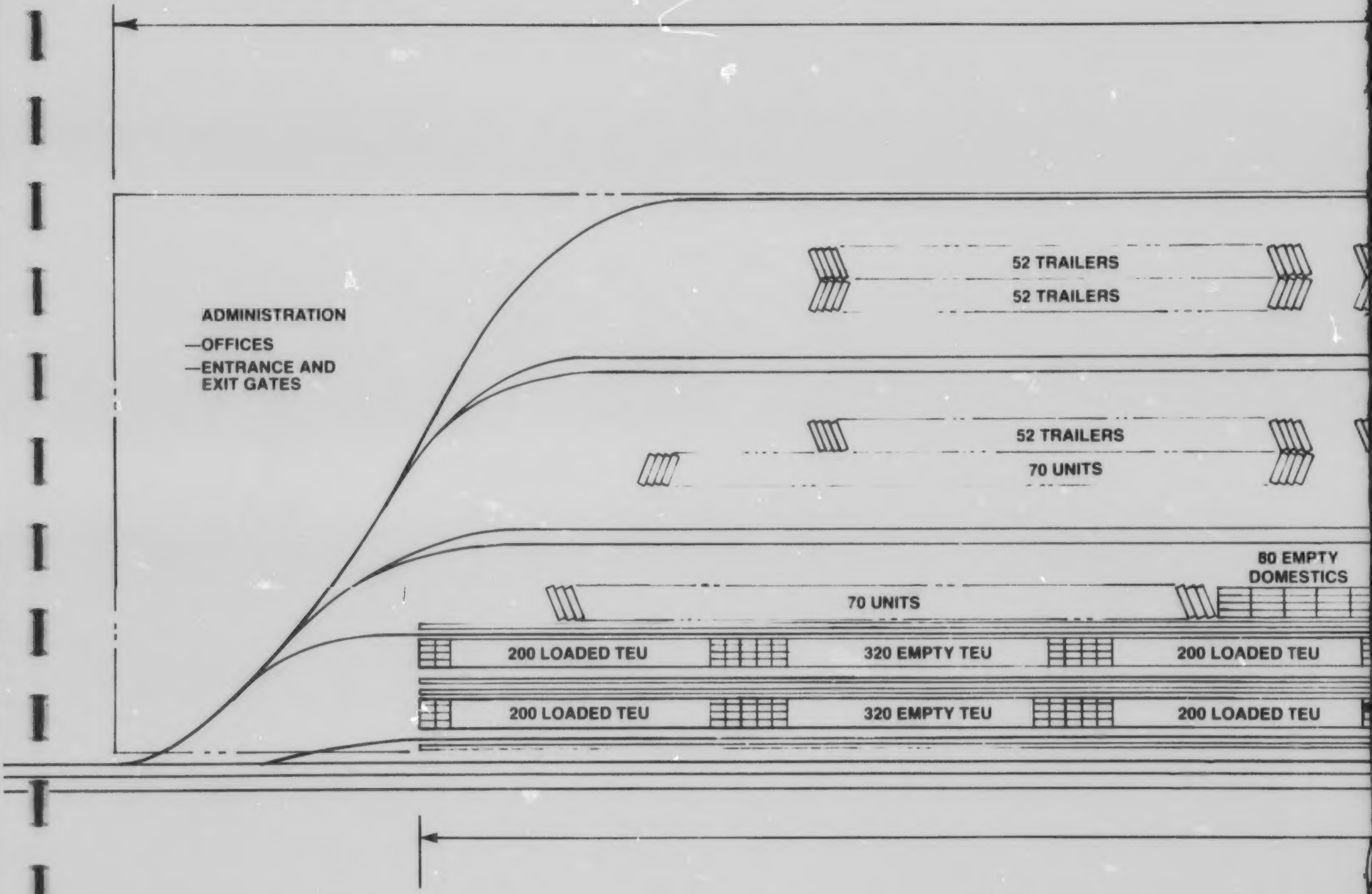
From the numbers of pieces of handling equipment and hostling and shuttling tractors determined in the previous sections, it is apparent that Case B1 is more cost effective because of the improved storage available in the working area. For this reason, it can be stated as a generalization that the integrated terminals with storage in the working area are more space efficient and have lower costs than the transfer terminals.

5.3.9 Case C3

This case represents a terminal designed using some of the findings mentioned above and constructed on a new site custom built to handle 400,000 units per year. It is based on the assumption that land is available in a location with the same relative proximity to the industrial centre of the metropolitan area so that there is no additional penalty for pick-up and delivery. It futher assumes that the site parallels the railway main line and that no additional transfer or switching penalties will be incurred. It is designed using 060 cranes for handling marine containers even though this option is more expensive than the one using toplifters (see Section 4.3 of Appendix III for the breakeven analysis). The case discussed in the next section (C4) uses toplifters for both marine and domestic containers. This comparison has been used to show the cost effectiveness of one design versus the other.

Each terminal configuration should be designed to reflect its specific traffic mix. In this case, the split of one-third each for trailers, marine containers, and domestic containers results in the trackage and storage capacity requirements shown in Table 1.5. If a design factor of 2 track turns per day is selected, the trackage requirements are as shown in Table 1.6.

Figure 1.9 illustrates one possible layout which satisfies the throughput requirements. It is very similar to the layout proposed in Case C1 with the exception that all storage of empty and loaded containers and trailers is located within the working area. This design feature is based upon the findings of the previous section and thus, eliminates the need for shuttling and minimizes the hostling requirements.


ADMINISTRATION
—OFFICES
—ENTRANCE AND EXIT GATES
52 TRAILERS
52 TRAILERS
52 TRAILERS
70 UNITS
80 EMPTY DOMESTICS
70 UNITS
200 LOADED TEU
320 EMPTY TEU
200 LOADED TEU
200 LOADED TEU
320 EMPTY TEU
200 LOADED TEU

SUMMARY

	TRACK				STORAGE	
	LENGTH REQUIRED	NO. OF TRACKS	LENGTH PROVIDED	TURNS PER DAY	REQUIRED	PROVIDED
MARINES	11,467 FT.	2	7,800 FT.	1.5	4,400	4,402
DOMESTICS	14,133 FT.	2	7,200 FT.	2.0	700	732
TRAILERS	20,533 FT.	3	10,400 FT.	2.0	613	624

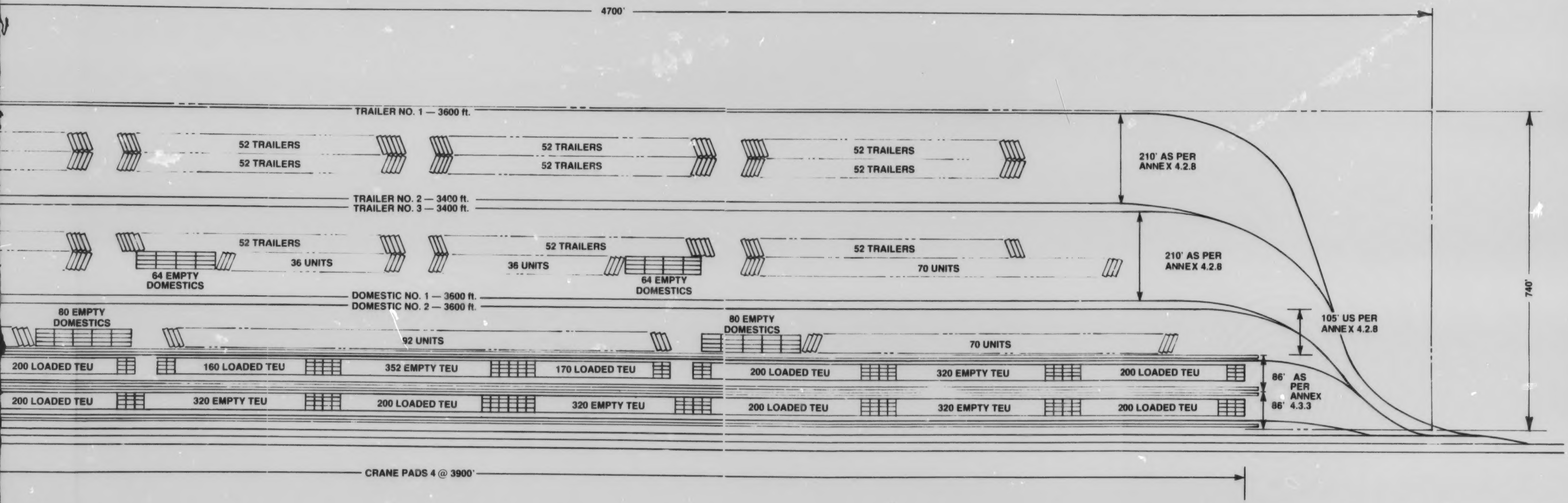

4700'
TRAILER NO. 1 — 3600 ft.
52 TRAILERS
52 TRAILERS
52 TRAILERS
52 TRAILERS
52 TRAILERS
52 TRAILERS
210' AS PER ANNEX 4.2.8
TRAILER NO. 2 — 3400 ft.
TRAILER NO. 3 — 3400 ft.
52 TRAILERS
36 UNITS
64 EMPTY DOMESTICS
52 TRAILERS
36 UNITS
64 EMPTY DOMESTICS
52 TRAILERS
70 UNITS
210' AS PER ANNEX 4.2.8
740'
DOMESTIC NO. 1 — 3600 ft.
DOMESTIC NO. 2 — 3600 ft.
80 EMPTY DOMESTICS
92 UNITS
80 EMPTY DOMESTICS
70 UNITS
105' US PER ANNEX 4.2.8
200 LOADED TEU
160 LOADED TEU
352 EMPTY TEU
170 LOADED TEU
200 LOADED TEU
320 EMPTY TEU
200 LOADED TEU
200 LOADED TEU
320 EMPTY TEU
200 LOADED TEU
320 EMPTY TEU
200 LOADED TEU
320 EMPTY TEU
200 LOADED TEU
86' AS PER ANNEX 4.3.3
86'
CRANE PADS 4 @ 3900'

Figure 1.9
Terminal Layout - Case C3

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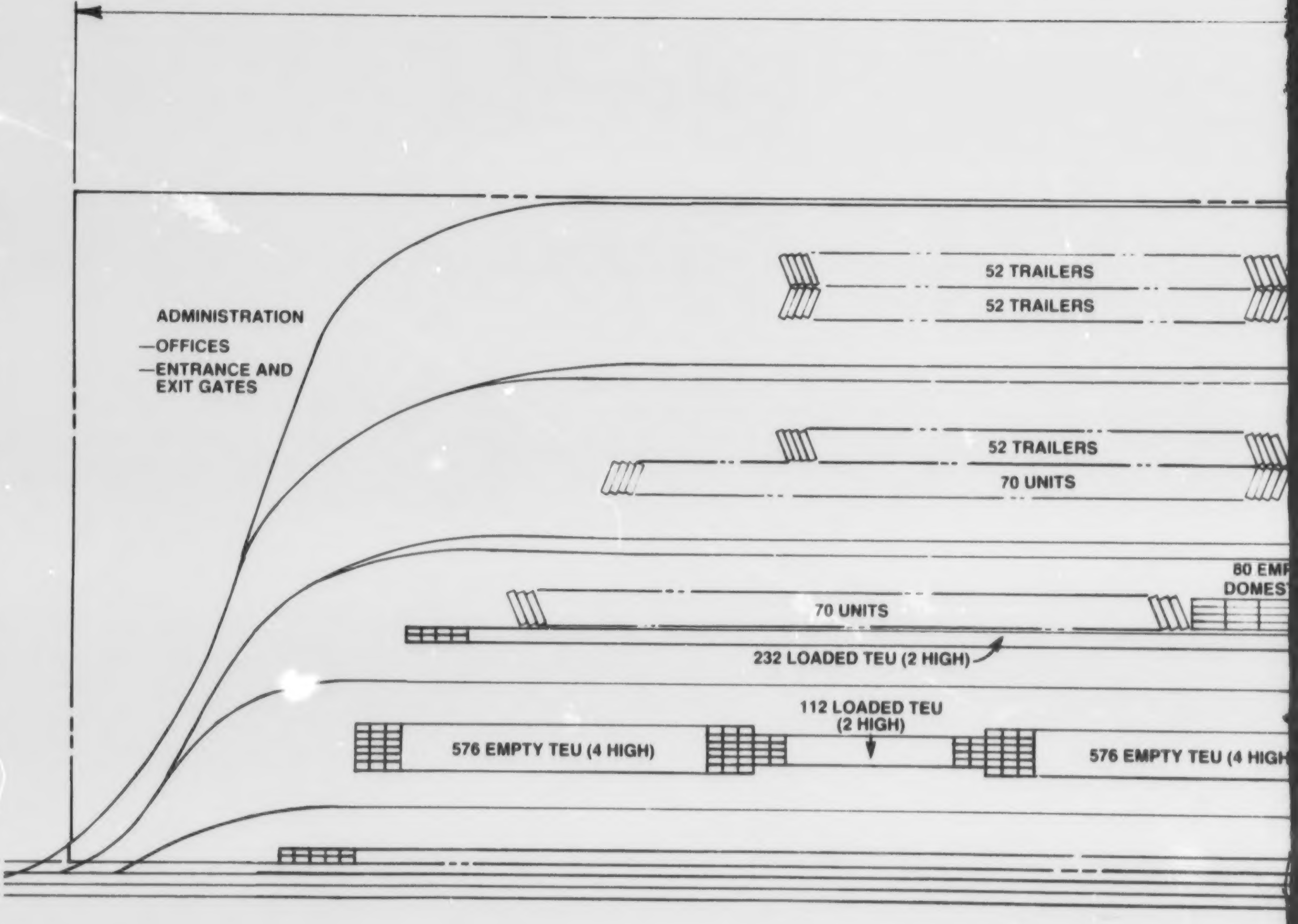
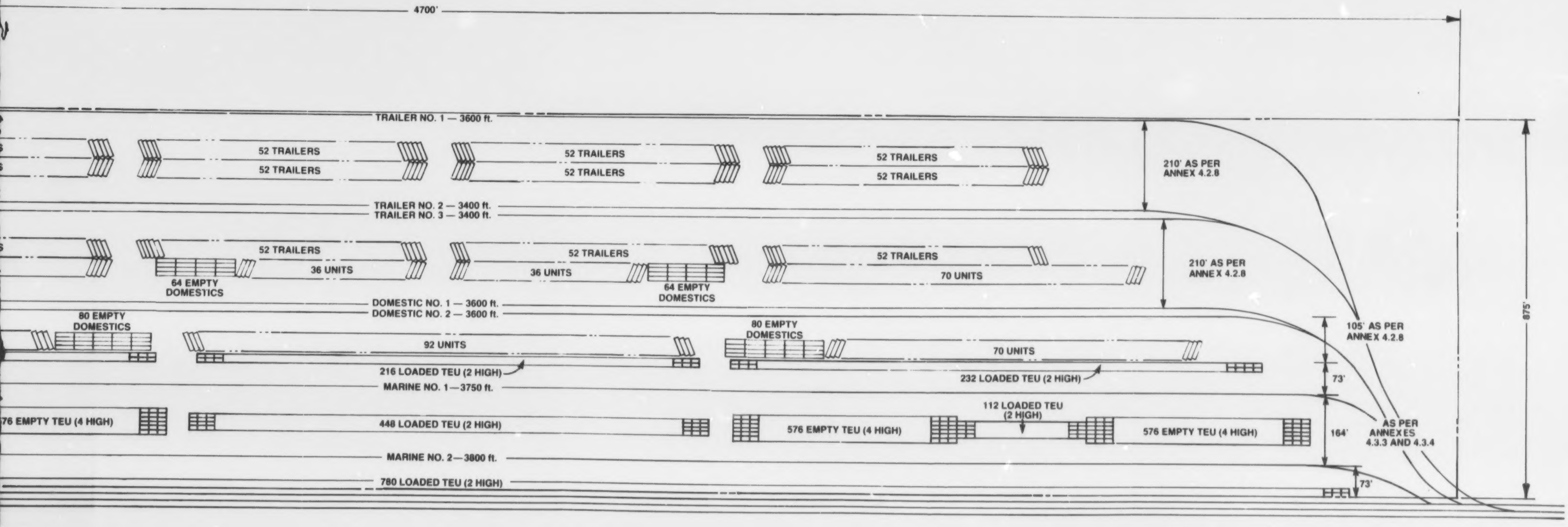
5.3.10 Case C4

This case is identical to Case C3 except that toplifters are used to handle marine containers rather than 060 cranes. Figure 1.10 illustrates one possible terminal layout based upon the premise that loaded marine containers are stacked in 2 X 2 piles to allow for selective retrieval while empty marine containers are block stacked in 3 X 4 high piles.


52 TRAILERS
52 TRAILERS
ADMINISTRATION
—OFFICES
—ENTRANCE AND EXIT GATES
52 TRAILERS
70 UNITS
80 EMP
DOMES
70 UNITS
232 LOADED TEU (2 HIGH)
112 LOADED TEU (2 HIGH)
576 EMPTY TEU (4 HIGH)
576 EMPTY TEU (4 HIGH

SUMMARY

	TRACK				STORAGE	
	LENGTH REQUIRED	NO. OF TRACKS	LENGTH PROVIDED	TURNS PER DAY	REQUIRED	PROVIDED
MARINES	11,467 FT.	2	7,550 FT.	1.5	4,400	4,436
DOMESTICS	14,133 FT.	2	7,200 FT.	2.0	700	732
TRAILERS	20,533 FT.	3	10,400 FT.	2.0	613	624



4700'
TRAILER NO. 1 — 3600 ft.
52 TRAILERS
52 TRAILERS
52 TRAILERS
52 TRAILERS
52 TRAILERS
52 TRAILERS
210' AS PER ANNEX 4.2.8
TRAILER NO. 2 — 3400 ft.
TRAILER NO. 3 — 3400 ft.
52 TRAILERS
36 UNITS
64 EMPTY DOMESTICS
52 TRAILERS
36 UNITS
64 EMPTY DOMESTICS
52 TRAILERS
70 UNITS
210' AS PER ANNEX 4.2.8
DOMESTIC NO. 1 — 3600 ft.
DOMESTIC NO. 2 — 3600 ft.
80 EMPTY DOMESTICS
92 UNITS
216 LOADED TEU (2 HIGH)
80 EMPTY DOMESTICS
70 UNITS
232 LOADED TEU (2 HIGH)
105' AS PER ANNEX 4.2.8
73'
MARINE NO. 1—3750 ft.
76 EMPTY TEU (4 HIGH)
448 LOADED TEU (2 HIGH)
576 EMPTY TEU (4 HIGH)
112 LOADED TEU (2 HIGH)
576 EMPTY TEU (4 HIGH)
164'
AS PER ANNEXES 4.3.3 AND 4.3.4
MARINE NO. 2—3800 ft.
780 LOADED TEU (2 HIGH)
73'
875'

Figure 1.10
Terminal Layout – Case C4

5.3.11 Summary of the Cases Studied

The development of the various cases in the previous sections follows the development of handling technologies available as the volumes have grown (and are expected to grow) for Terminal 'X'. Case A presents an analysis of a medium sized terminal (100,000 units per year) utilizing first generation technology - ramps and toplifters. As the volume of traffic increases towards the present levels of 150,000 units per year, the high space and switching requirements of the ramp layout become so restrictive for the area available that the empty annex is required and the requirements for shuttling and hostling increase substantially.

The introduction of piggypackers for handling trailers allows a much more space efficient layout to be installed. The space and yard switching savings are such that the existing site is adequate for an annual throughput in excess of 200,000 units per year without requiring a remote off-site area for the storage of empty containers.

Further increases in traffic volumes to the 400,000 units per year level strain the capacity of the existing site to the limit, even with the introduction of high density 060 cranes for handling marine containers. The capacity of the existing facility appears to be approximately 225,000 units per year based upon the space required for Case B1. Beyond this limit, the use of a remote off-site storage is required and consideration should be given to a new site based upon the layout presented for Case C4.

One of the greatest advantages of providing a run-through integrated terminal with sufficient trackage to keep the turnaround to a maximum of 2.0 is that it allows the road locomotives to handle a good portion of the terminal switching and helps to reduce the use of switch engines at the terminal. The use of road locomotives to double or triple their trains at the terminal will work only at high volume levels which in turn will allow the operation of more single or double destination trains.

An alternative to a new site for all traffic would be a splitting of the traffic handled at the existing terminal and at a new site, either by service (marine containers at one site and trailers and domestic containers at the other) or by destination (east at one and west at the other). This study does not, however, consider the split terminal concept further.

5.4 Cost Model

The annual cost of any terminal operation is composed of two basic elements, the annual operating costs and the annual carrying charges for the asset investments.

Although the cost factors directly related to the operation of a terminal are not large; the size, location, configuration and operating practices employed at the terminal will affect the costs of related non-terminal activities. These charges include pick-up and delivery on the one hand, and railway costs such as switching and yard transfer costs. This study does not consider these related costs.

Tables 1.7 and 1.8 outline the different cost both capital carrying charges and annual operating costs related to each of the 8 cases considered. Figure 1.11 presents a graphic breakdown of these costs.

Table 1.7 Capital Cost Estimates ($000) - All Cases

Asset	Unit Cost	Present 150,000 Units		Case A 100,000 Units		Case B1 200,000 Units		Case B2 200,000 Units		Case C1 400,000 Units		Case C2 400,000 Units		Case C3 400,000 Units		Case C4 400,000 Units	
		U	$	U	$	U	$	U	$	U	$	U	$	U	$	U	$
1) Land	$200,000/acre	61	12,200	40	8,000	51	10,200	51	10,200	60	12,000	78	15,600	80	16,000	94	18,800
2) Site Preparation	$ 75,000/acre	40	3,000	40	3,000	51	3,825	51	3,825	60	4,500	78	5,850	80	6,000	94	7,050
3) Paving			6,875		4,375		5,625		5,625		7,000		9,150		8,950		11,750
4) Buildings			365		365		380		380		660		660		660		660
5) Track and Ramps, etc.			2,355		1,818		1,971		2,325		2,171		3,780		3,570		3,570
6) Improvements			1,400		1,010		1,235		1,235		1,630		1,895		1,895		2,140
7) Management Systems							225		225		450		450		450		450
8) Handling Equipment			3,200		1,800		5,900		5,900		23,500		17,700		20,450		7,600
9) Underpass	$ 62,500 each *	-	-	-	-	-	-	-	-	1	63	-	-	-	-		-
10) Total			30,970		20,368		29,361		29,715		51,974		55,085		57,975		52,020
11) Weighted Average CVCOC Factor			0.19887		0.19790		0.19858		0.19813		0.19913		0.19865		0.20006		0.20027
12) Annual Capital Carrying Charge			6,159		4,031		5,831		5,888		10,350		10,943		11,599		10,418

(*) railway portion

Table 1.8 Annual Terminal Operating Costs ($000) - All Cases

Activity	Unit Cost	Present 150,000 Units		Case A 100,000 Units		Case B1 200,000 Units		Case B2 200,000 Units		Case C1 400,000 Units		Case C2 400,000 Units		Case C3 400,000 Units		Case C4 400,000 Units	
		U	$	U	$	U	$	U	$	U	$	U	$	U	$	U	$
1) Administration	(1)	-	1,200	-	1,000	-	1,200	-	1,200	-	1,380	-	1,380		1,380		1,380
2) Machine Operators and Fuel	$26,500 per operator (2)	10	265	7	186	19	494	19	494	31	775	29	725	25	625	22	550
3) Groundmen, Foremen, Utilitymen	$2.00 per unit handled	-	300	-	200	-	400	-	400	-	800	-	800	-	800	-	800
4) Equipment Repairs	12% of 8 in Table 4.29 (5)	-	384	-	216	-	708	-	708	-	2,060	-	1,824	-	1,794	-	912
Subtotal			2,149		1,602		2,802		2,802		5,015		4,729		4,599		3,642
5) Miscellaneous Charges	42% of Subtotal	-	903	-	673	-	1,177	-	1,177	-	2,106	-	1,986	-	1,932	-	1,530
6) Hostling Costs	$107,000 (3) per driver	7	749	5	535	7	742	8	848	15	1,575	18	1,890	13	1,365	13	1,365
7) Shuttling Costs	$107,000 (3) per driver	3	321	-	-	-	-	-	-	5	525	20	2,100	-	-	-	-
8) Annual Capital Carrying Charges	See Table 4.29	-	6,159	-	4,031	-	5,831	-	5,888	-	10,350	-	10,943	-	11,599	-	10,418
Total Terminal Operating Costs			10,281		6,841		10,552		10,715		19,571		21,648		19,495		16,955
Total Terminal Operating Costs Per Unit			$68.54		$68.41		$52.76		$53.58		$48.93		$54.12		$48.74		$42.39
9) Pick-up and Delivery; Highway Haul	$100 per unit handled (4)	-	9,000	-	6,000	-	11,760	-	11,760	-	23,280	-	23,280	-	23,280	-	23,280
10) Switching Charges	$90,000 per weekly shift	23	2,070	8	1,620	18	1,620	8	1,620	3	2,070	8	1,620	3	1,170	3	1,170
Total Beyond Rail Haul Costs			21,351		14,461		23,932		24,095		44,921		46,548		43,945		41,405
Total Beyond Rail Haul Costs per Unit			$142.34		$144.61		$119.66		$120.48		$112.30		$116.37		$109.86		$103.5

(1) See Section 5.7, Appendix II.

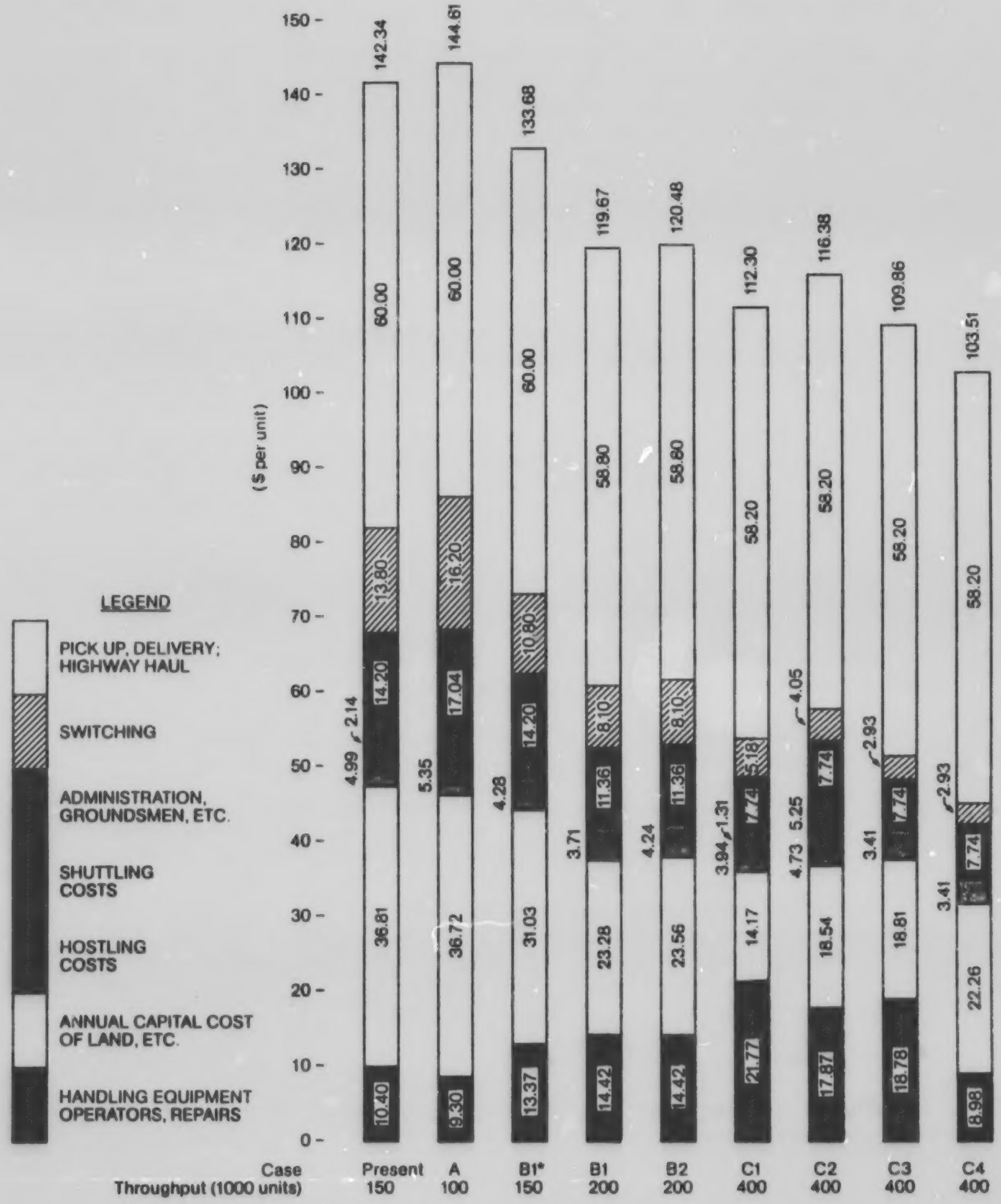
(2) See Section 5.7, Appendix II. The unit cost reduces to $26,000 per machine and $25,000 per machine for the B and C cases respectively.

(3) See Section 5.7, Appendix II. The unit cost reduces to $106,000 per driver and $105,000 per driver for the B and C cases respectively.

(4) See Section 5.7, Appendix II. The unit cost reduces to $98 per unit and $97 per unit for the B and C cases respectively.

(5) 000 cranes assumed to be 10 percent of capital cost and 080 cranes 7 percent.

Figure 1.11 Cost Breakdown by Major Components for the Cases Studied



* (Case B1 Piggybacker Operation at 150,000 units/year)

6. Conclusions

The general conclusions reached as a result of the preceeding sections on terminal configurations, operating concepts, and handling equipment are as follows:

a) integral terminals with storage in the working area are more economical than transfer terminals with storage in remote locations because the integral terminal is more efficient in terms of space requirements and less on-site hostling is required.

b) for handling trailers, piggypackers are more efficient than hostlers operating on circus loading ramps, however, they cannot really be justified until an annual throughput of approximately 70,000 trailers is attained. This statement is based upon the assumption that a minimum of 2 machines are required to guard against breakdowns. Some terminals operate with one unit only and the terminal stops operating when breakdowns occur.

c) 060 cranes for handling marine containers and which permit storage under the span cannot be justified until the cost of land (including preparation and paving) exceeds a minimum of $1,000,000 per acre; otherwise toplifters are more economical.

d) cranes for handling trailers do not appear to be economically viable.

Generally speaking, therefore, the most effective layouts for high volume terminals are as follows:

- trailers handled by piggypackers and utilizing 2 centre storage aisles;
- domestic containers handled by toplifters and utilizing 2 centre storage aisles for containers on chassis or empty chassis, or 8 rows of empty containers stored 4 high;
- marine containers handled by 060 cranes (assuming very expensive real estate values) and utilizing a 2-3-3-2 high storage configuration for loaded containers and a 4-4-4-4 configuration for empty containers. For less expensive land values, toplifters storing loaded marine containers in 2 X 2 piles and empty containers in 3 or 4 X 4 high piles are more economical.

These conclusions are developed in more detail in the following sections.

6.1 Terminal Operating Philosophy

The decision as to whether to operate an integral terminal (with storage within the working area) or a transfer terminal (with storage in a remote location) is easily made after reviewing the relative space efficiencies of the standard layouts presented in the annexes to Appendix III. In all cases, the integral terminals were more space efficient and required less hostling. Furthermore, a comparison of the costs for the expansion cases B1, B2, C1, and C2 as presented in Table 1.8 also showed that the integral cases (B1 and C1) were more economical than the transfer cases (B2 and C2). For the ideal Terminal 'X', therefore, the integral concept was used.

Circus loading ramps are not space efficient and require a high degree of hostling and are recommended only for small volume, low capital cost installation.

6.2 The Introduction of Piggypackers

Because of the high capital cost of piggypackers, they should be introduced only when they can be utilized fully. It is unwise to base an operation on only one machine because a failure can effectively shut down the operation. The minimum investment should be, therefore, 2 machines so that the terminal may still operate on an emergency basis in the event that one machine goes down for maintenance reasons.

For an operation like Terminal 'X' with one-third each for trailers, domestic containers and marine containers, the threshold volume for the acquisition of piggypackers is approximately 210,000 units per year. For terminals handling only trailers and marine containers, (i.e. no domestic containers), the threshold volume reduces to approximately 110,000 units per year. These limits are theoretical, however, and assume that there is enough space in the terminal to operate an integral terminal without hostling to a remote on-site storage area or shuttling to a remote off-site location.

In the case of the present Terminal 'X', these throughput threshold volumes are much lower because the shortage of space at the main terminal forces the terminal manager to shuttle containers to the empty annex (remote off-site location). In this instance, it is better to remove the circus loading ramps at a smaller annual volume and to tolerate some under-utilization of the piggypackers in exchange for saving the shuttling costs.

Recalculating the B1 case at 150,000 units per year gives an average unit cost of $133.68. Since the Case A average cost per unit was $144.61 at 100,000 units and the present case cost $142.34 at 150,000 units, the threshold volume for this terminal appears to be (by interpolation) approximately 110,000 units per year. At this volume the annual operating costs for the piggypacker and circus loading cases are approximately identical.

6.3 The Introduction of 060 Cranes for Marine Containers

The most space efficient layouts for toplifters handling containers in integral terminals and for 060 cranes handling marine containers are shown in Appendix III. Although the 060 cranes are more space efficient, the higher capital costs and slower handling capabilities mean that the 060 cranes should be installed only where land value are high enough to withstand these drawbacks.

The equipment requirements of the C cases were used for the analysis of threshold land values. The threshold land value was determined by equating the cost of land, equipment (including repair costs) and operators and fuel for the two cases being considered. The areas required for the toplifter case assumed high density 4 X 4 storage piles for empties and 2 X 2 piles for loads.

The threshold value thus determined was far higher than the present value of land at Terminal 'X' of $400,000 per acre including site preparation, paving, fencing, floodlights, etc. Even if 3 X 3 storages piles are handled by toplifters, the threshold land value still remains high at $1,025,541 per acre. As such, any new facility built near Terminal 'X' should use toplifters. This statement can be verified by comparing the terminal operating costs for the C3 and C4 cases in Table 1.8.

6.4 The Introduction of 030 Cranes for Trailers

An analysis, similar to the one made in the previous section, was made to compare the use of 030 cranes rather than piggypackers for handling trailers. In this example there was no space advantage to the use of 030 cranes, in fact, there was a slight penalty, 1,719 sq.ft. per trailer for 030 cranes and 1,413 sq.ft. per trailer for piggypackers. Since 030 cranes cost considerably more than piggypackers ($1,250,000 versus $550,000) and because there are no handling improvements available by using them, there is no economic justification for using 030 cranes for integral terminals. The use of 030 cranes may provide some advantage in specialized applications such as "sprint" operations or in transfer terminals where the narrow width of the property precludes the establishment of integral terminals. These cases must be evaluated on their own merits.

6.5 The Introduction of 060 Cranes for Trailers

This operation may be feasible in locations where land is scarce and real estate values are high. Trailers could be stored parallel to the tracks under the crane span and would have to be selectively retrieved for delivery or loading onto rail cars (in other words treated like containers). Eight trailers could be stored under the crane span in a 100-foot section of 2-track module (8,600 square feet) and the resulting space requirements would be 1,075 square feet per trailer. Because most of the trailers would require 2 cycles to be handled, the same 50 percent reduction from cycles to handlings that was made for marine containers handled by cranes must be used and an average handling rate of 48 trailers per peak unloading period results.

The threshold land value was determined to be $2,800,000 per acre by equating the annual cost of land, equipment, operators and fuel, and repairs as was done in Section 6.3. Again, because the threshold land value needed to justify the installation of 060 cranes is so high, it is not surprising that they are seen mainly in the industrial centres of very large cities and in busy harbours where land values can justify the high capital costs. The use of 060 cranes for trailers, however, cannot be justified.

6.6 General Observations

The cases studied in this report have shown that an almost infinite number of combinations can be studied. Every change in these factors also affects shuttling, hostling, and switching costs for the same terminal location. For this reason it is not possible to produce a generalized model of the "ideal" intermodal terminal.

For any given terminal layout, manual simulation techniques seem to offer a low cost method of determining the capacities and bottlenecks for any configuration and number of pieces and types of equipment. The peak day and peak hour traffic patterns should be determined for each terminal being studied as was done in Appendix I since the arrival and departure patterns at each terminal may vary. Sophisticated computer-based simulators do not appear to be necessary when studying only one terminal or when extrapolations are not needed. However, the computer based simulation techniques would offer considerable benefits when more than one terminal is considered, or when multiple iterations are required.

The advantage of computer-based simulators lies in their ability to quickly run through many changes in variables and determine their effect on the terminal configurations under consideration, the operating procedures and other factors. (Annexes I,II and III of Appendix I outline in more detail the requirements for a computer-based simulation model for road/rail intermodal terminals as well as two simulation packages now in operation in Great Britain)

The cost calculations have produced the following recommendations for the specific traffic mix and volumes being handled by Terminal 'X'.

- the existing circus loading ramps should be replaced with a piggypacker operation as soon as the capital is available.
- the use of toplifters for marine containers should be continued because 060 cranes are too expensive for present land values.

These 2 recommendations correspond roughly to Case B1 (see Figure 1.5). These changes will reduce operating costs significantly and will increase the ablity of the terminal and the existing empty annex to handle volume increases up to at least 225,000 units per year. Beyond this level, either a new site should be considered based upon Case C4 or a split terminal operating should be inaugurated.

Before any terminal changes are contemplated, however, simulations should be run again with the new equipment, trackage, and volumes anticipated in order to confirm the capacity of the terminal and to identify any unforeseen bottlenecks or constraints. Also, the simulation exercise should be expanded to include the terminal, make-up and yard tracks and to check on the ability of the switch engines and road units to handle to new tonnage in what will probably be more single and double destination trains.

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TP - 4059E

INTERMODAL TERMINAL DESIGN STUDY

BY

CANADIAN PACIFIC LIMITED
MARCH 1983

APPENDICES

PREPARED FOR THE TRANSPORTATION DEVELOPMENT CENTRE

TP-4059E

INTERMODAL TERMINAL DESIGN STUDY

APPENDICES

PREPARED
BY

CANADIAN PACIFIC LIMITED

FOR

THE TRANSPORTATION DEVELOPMENT CENTRE

MARCH 1983

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"The contents of this report reflects the views of the contractor and not necessarily the official views or policies of the Transportation Development Centre".

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REPORT DOCUMENTATION FORM

1. Transport Canada Report No. Tp 4059E	2. TDC Project No. 8937	3 Recipient's Catalogue No

4. Title and Subtitle

INTERMODAL TERMINAL DESIGN STUDY
Appendices

5 Report Date
March 1983

6 Performing Organization Report No

7. Author(s)
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8 Transport Canada File No
D1465-285-15

9. Performing Organization Name and Address

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10 DSS File No
09SD T8200-8-8552

11 DSS or Transport Canada Contract No
0SD 79-00045

12. Sponsoring Agency Name and Address

TRANSPORTATION DEVELOPMENT CENTRE (TDC)
1000 Sherbrooke Street West
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13 Type of Report and Period Covered
Sept. 1979-March 1983

14 Sponsoring Agency Code
TDC 8937

15. Supplementary Notes
The final Report is separately bound

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17. Abstract

Appendix I, TERMINAL CAPACITY ANALYSIS, concerns the study of terminal traffic flows, and a survey of the different operating factors affecting a major Canadian terminal. Using the information gathered, the terminal operations were simulated for a day and found adequate for receiving traffic. The traffic forwarded, however, created problems because of cut-off times. It is recommended that additional tracks be laid both for the handling of units and for the access to the terminal from the main line. Also, terminal operating procedures should be reviewed to improve the coordination of the different operations.

Appendix II, TERMINAL MANAGEMENT SYSTEMS, looks at the possibilities of computerizing the information required for the efficient management of terminal operations. The first element to be implemented is an inventory system which would keep track of the status and location of intermodal equipment. The second element should address the interchange of units from both the rail and rail systems into the terminal. Finally, a record-keeping system should be implemented.

Appendix III, COST MODEL, studies the design of terminal facilities, taking into account land area, storage requirements, track requirements and related costs. The most efficient configuration is a double-entry integral terminal with storage in the working area with side-loading equipment for both trailers and containers.

Appendix IV, INTERMODAL TRANSPORTATION AND HANDLING EQUIPMENT, includes captioned photographs of the different equipment in use in an Intermodal Operation. Also included are photographs of state-of-the-art or proposed equipment such as high-rise, high-density container storage facilities and automated storage and transfer facilities.

18. Key Words Intermodal, Terminals, Traffic Flow, Handling Cycles, Management, Design, Expansion	19. Distribution Statement Limited number of copies available from TDC or CP Ltd.

20. Security Classification (of this report) Unclassified	21. Security Classification (of this page) Unclassified	22 No. of Pages 323	23. Price NIL

TDC/CDT 79-005

FORMULE DE DOCUMENTATION POUR RAPPORT

1. Nº du rapport Transports Canada
TP 4059E

2. Nº de l'étude — CDT
8937

3. Nº de catalogue du destinataire

4. Titre et sous-titre
INTERMODAL TERMINAL DESIGN STUDY
Appendices

5. Date du rapport
Mars 1983

6. Nº du rapport de l'organisme exécutant

7. Auteur(s)
Ives C.J.M., Dale J.C., et al

8. Nº de dossier Transports Canada
D1465-285-15

9. Nom et adresse de l'organisme exécutant
CANADIEN PACIFIQUE LIMITEE
C.P. 6042, succursale "A"
Montreal, Quebec H3C 3E4

10. Nº de dossier — ASC
09SD T8200-8-8552

11. Nº de contrat — ASC ou Transports Canada
0SD79-00045

12. Nom et adresse de l'organisme parrain
Centre de Developpement des transports (CDT)
1000 ouest, rue Sherbrooke
Suite 2421
Montreal, Quebec H3A 2R3

13. Genre de rapport et période visée
sept. 1979-mars 1983

14. Code de l'organisme parrain
CDT 8937

15. Remarques additionnelles
Rapport principal: "Intermodal Terminal Design Study", 2 Volumes, mars 1983, TP 4059E

16. Agent de projet — CDT
T. Smith (M. Tapiero)

17. Résumé

L'appendice I, TERMINAL CAPACITY ANALYSIS (Analyse de la capacité d'un terminal), comprend l'étude du trafic d'un terminal et un relevé des divers facteurs influençant l'exploitation d'un grand terminal canadien. A l'aide des informations recueillies, l'exploitation d'une journée a été simulée et il s'est avéré que les installations suffisent au trafic quotidien. Le trafic expédié a toutefois causé des problèmes à cause de l'heure limite de remise. Il est recommandé que des voies supplémentaires soient installées à la fois pour manipuler le matériel et pour accéder au terminal en provenance de la ligne principale. De plus, les méthodes d'exploitation du terminal devraient être revisées dans le but de mieux coordonner les différentes manoeuvres.

L'appendice II, TERMINAL MANAGEMENT SYSTEMS (Les systèmes de gestion d'un terminal), analyse les possibilités d'informatiser le système de gestion d'exploitation d'un terminal. Le premier élément introduit serait un système d'inventaire permettant de repérer tout le matériel inter-modal et d'en donner la situation. Le deuxième élément concerne le passage du matériel des rails et du réseau ferroviaire au terminal. Enfin, un système pour tenir à jour les dossiers devrait être mis sur pied.

L'appendice III, COST MODEL (Exemple des coûts), étudie la conception des aménagements du terminal en tenant compte de l'emplacement du terrain, des besoins reliés au stockage et aux rails ainsi que des coûts s'y rattachant. La configuration offrant le meilleur rendement serait un terminal intégré à double accès avec aires de stockage sur le chantier et utilisant un équipement de chargement latéral des remorques et des conteneurs.

L'appendice IV, INTERMODAL TRANSPORTATION AND HANDLING EQUIPMENT (Matériel inter-modal de transport et de manutention), présente des photographies et légendes du matériel utilisé pour l'exploitation d'un terminal inter-modal. S'y trouvent aussi des photographies du matériel le plus récent ou du matériel proposé pour le stockage en hauteur et de haute densité des conteneurs ainsi que des aménagements pour le stockage et le transfert automatiques.

18. Mots-clés
Intermodal, Terminaux, Courants de Trafic, Cycles de Manutention, Gestion, Conception, Agrandissement

19. Diffusion
Un nombre limite ce copies est disponible au CDT ou chez CP LTEE

20. Classification de sécurité (de ce rapport)
Non-classifié

21. Classification de sécurité (de cette page)
Non-classifiée

22. Nombre de pages
323

23. Prix
Nul

CDT/TDC 79-006

ACKNOWLEDGEMENTS

The team members of this project wish to acknowledge the advice and support of the following organizations who contributed of their time and expertise to this study:

CP Limited
- CP Rail - Intermodal Services
- Information Systems
- CP Rail - Operations Development
- CP Rail - Communications
- Systems Services

Transport Canada - Transportation Development Centre

Railway Advisory Committee (RAC)

CN Rail
- Intermodal Services
- Operations Research & Industrial Engineering

U.S. Federal Railways Administration, Washington, D.C.
Office of Freight Systems

Systems Control Inc.

Mersey Docks & Harbours Board - Great Britain

British Rail Freightliners

Luke, Malone & Associates Ltd. (Graphics)

INTRODUCTION TO THE APPENDICES

The Intermodal Terminal Design Study included original research undertaken in three different areas:

- Terminal Capacity Analysis
- Terminal Management Systems
- A Cost Model of Expanded Facilities

For the sake of completeness, the reports concerning these areas have been incorporated as Appendices to the Final Report of the INTERMODAL TERMINAL DESIGN STUDY.

A general table of contents at the beginning of this volume outlines the major headings of each Appendix. A more detailed Table of Contents including the list of tables and figures for each appendix can be found preceeding the Appendix it relates to.

The final Appendix (Appendix IV - Intermodal Transportation and Handling Equipment) includes captioned photographs of the different equipment in use in an Intermodal Operation. Also included are photographs of state-of-the-art or proposed equipment such as high-rise, high-density container storage facilities and automated storage and transfer facilities.

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1. INTRODUCTION

1.1 Objective

The contract between CP Limited and Tranportation Development Centre which governs the study specifies the following objective:

> "The main purpose of this project is to design an optimal terminal applicable to major Canadian cities having due regard to land values and making apropriate use of new technology... and data systems."

1.2 Achievement of the Objective

Appendix II "Terminal Management System" documents the data systems aspect of Intermodal Terminal Design. It identifies the functions required for a computer-based Terminal Management System (TMS) which would be needed to achieve effective expansion of present facilities.

Appendix III "Cost Model" outlines some terminal design and expansion strategies taking into account land area, handling equipment, storage and truckage requirements as well as capital and operating costs. A typical terminal, designated as Terminal 'X' was expanded from a 100,000-unit annual handling capacity to a 400,000-unit capacity to illustrate how a terminal throughput capacity can be increased.

This appendix documents a systems approach to designing intermodal road-rail facilities. The traffic volumes of a specific terminal and the handling cycles of varying equipment were studied to determine the factors which most affect the operation of a terminal and provide data for the further study of terminal design or expansion strategies.

1.3 Approach Used for the Study

The physical capacity of an intermodal terminal may be defined as the terminal's ability to:

- forward and receive trailers and containers by rail on a current basis;
- transfer trailers and containers to and from rail cars;
- store trailers and containers;
- process trailers and containers arriving or departing by road.

In order to fulfill the objectives of the study, it was decided that the best approach would be to simulate annually the operation of the terminal on the basis of a five-year traffic forecast to 1984.

An estimate of future daily volumes and storage requirements was determined using the forecast annual handlings to 1984. This daily handling information was then compared to the capacity of the existing facility through manual simulation.

1.3 Approach Used for the Study (continued)

The results suggested many modifications which could be made in the short term to meet the increases in handling forecast.

It was then assumed that all short term modifications were implemented prior to re-simulating the revised terminal against the 1985 forecasted handlings.

Once an optimal allocation of the terminal area to track, storage, roadways, inspection areas and transfer areas was determined, the terminal was operated for one day by a manual simulation to determine the operating procedures. The equipment for transferring trailers and containers to and from rail cars was also evaluated at this time.

The results of the capacity study and the manual simulation became the basis for making recommendations for formulating management policy.

1.4 Data Collection

Meetings were held with the management of Terminal "X" on September 16 to 18, 1979 to discuss and decide on the methods to be used to gather the information for the capacity study. The collection period chosen was September 30 to October 6, 1979. Historically the terminal is busiest from September to November and the collection period was selected to reflect these peak months.

2. TRAFFIC FORECAST TO 1984

2.1 Projected Terminal Handlings - All Plans

The basis upon which the capacity requirements of the terminal were determined was the five-year traffic forecast. The projected terminal handlings for the period 1980 - 1984 are shown below:

Table 2.1: Projected Terminal Handlings - All Plans

	1980	1981	1982	1983	1984
Trailers	82,958	82,120	79,786	74,456	72,528
Domestic Containers	4,500	17,400	32,000	50,000	66,000
Marine Containers	65,757	69,045	71,116	73,250	75,447

This estimate in traffic growth was based upon the traffic moving between the various origin-destination pairs in 1979. The growth in Plan II traffic moving in trailers in 1979 has been divided into Domestic Containers and Plan II trailer traffic.

Assuming that sufficient empties return to the terminal for loading outbound traffic, the handlings expected at Terminal 'X' in 1984 are as listed in Tables 2.2 and 2.3 below:

Table 2.2 1984 Annual Handlings - Inbound

	Trailers			Domestic Containers	
Origin	Plan I & III	Plan II (Trailers)		Plan II	
	Loads	Loads	Empties	Loads	Empties
East	8,414	2,753	1,607	6,147	3,588
West	10,939	4,882	5,535	10,902	12,363
	19,353	7,635	7,142	17,049	15,951
		14,777		33,000	

Table 2.3 1984 Annual Handlings - Outbound

	Trailers		Domestic Containers
Destination	Plan I & III	Plan II (Trailers)	Plan II
East	8,073	4,361	9,736
West	15,548	10,416	23,264
	23,621	14,777	33,000

An origin-destination handling table was not prepared for marine containers as the majority of these movements originate and terminate at Montreal Wharf or Saint John, N.B.

2.2 Peak Weekly Handlings

Based upon the monthly handlings in 1978 and 1979, the ratio of handlings in the peak months to annual handlings is as shown in Table 2.4 below.

Table 2.4 Monthly Handling Factors

Type Of Traffic	Factor
Trailers	
Plan I & III	12%
Plan II	10%
Domestic Containers	10%
Marine Containers	
Plan II	12%
Marine	
In	10%
Out	10%

These factors were applied to the estimated 1984 annual handlings in order to determine the monthly handlings. The maximum weekly handlings were developed by assuming uniform traffic over the peak month based on a 30-day month, 7-day week.

2.3 Peak Daily Handlings - Trailers and Domestic Containers

The daily train operation sheets prepared for the period of October 1, 1978 to September 30, 1979 (excluding the strike period of July 6, 1979 to August 15, 1979) were used to develop a distribution of trailers (all plans) forwarded by day of the week. It was assumed that these factors would also apply to Domestic Containers. These factors are as follows:

Table 2.5 Trailers and Domestic Containers Forwarded by Day

Day of the Week	Forwardings
Monday	16%
Tuesday	18%
Wednesday	18%
Thursday	18%
Friday	19%
Saturday	11%
Sunday	-
	100%

It was assumed that the same factors would apply to traffic forwarded from other terminals.

The arrivals were developed by applying the factors to the traffic originating at the terminals shown in Table 2.2 and allowing the transit times shown below:

Table 2.6 Symbol Train Transit Times

Origin	Transit Time
Vancouver	5th Day
Calgary	4th Day
Winnipeg	3rd Day
Thunder Bay	2nd Day
Edmonton	5th Day
Saskatoon	4th Day
Regina	4th Day
Lethbridge	4th Day
Montreal	Next Day
Saint John	3rd Day

The cumulative frequency distribution of trailer flat cars forwarded by day of the week for the period from October 1, 1978 to September 30, 1979 are shown in Figure 2.1.

2.4 Peak Daily Handlings - Marine Containers

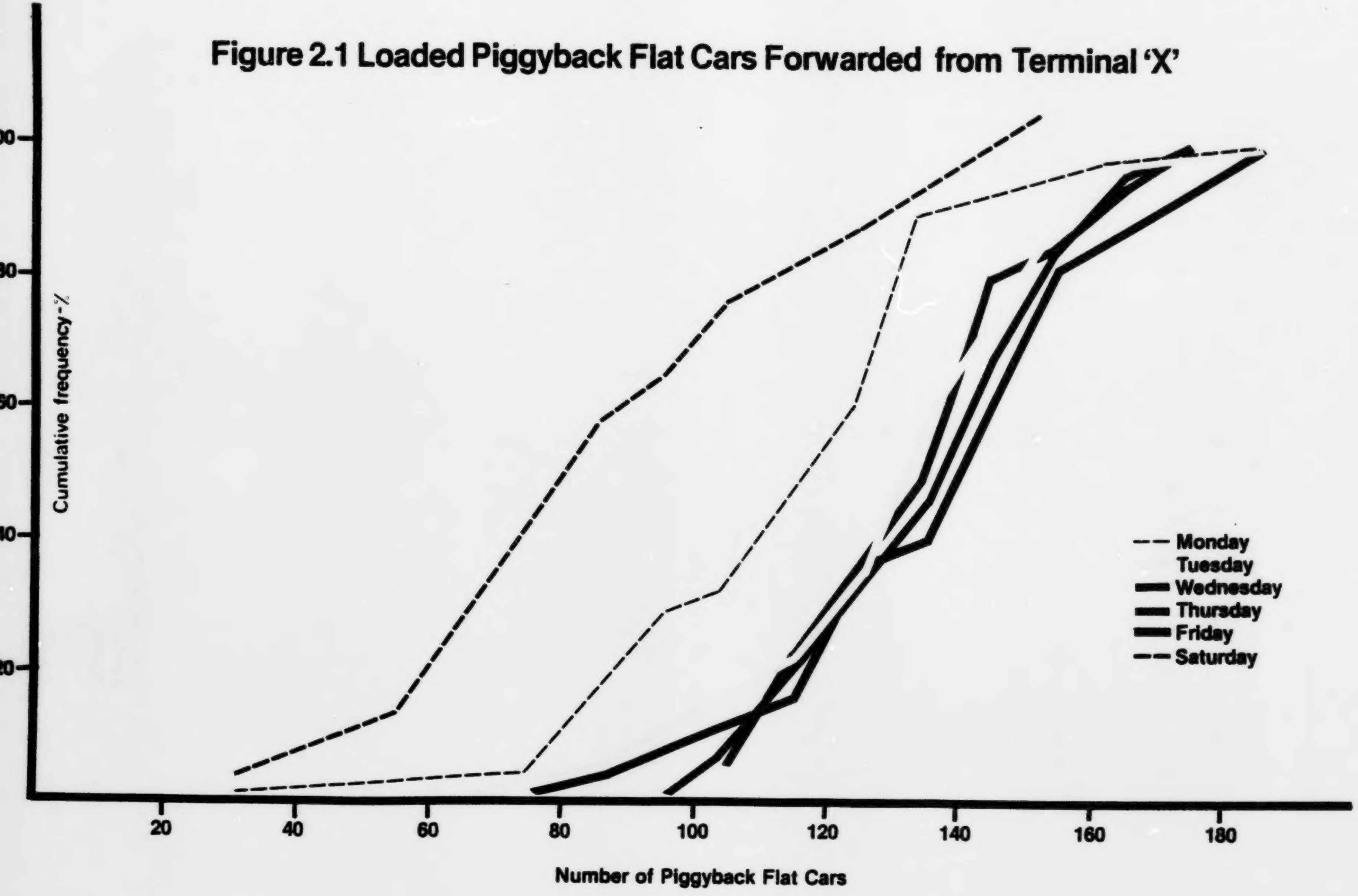
There is no direct relationship between the number of marine containers received and forwarded by rail and the day of the week; however, the probability that the maximum daily marine container handlings in a one-week period will occur on a given day is shown below:

Table 2.7 Probability that the Maximum Number of Marine Container Handlings Will Occur on a Given Day

Day of the Week	Probability that Peak Will Occur on Day of the Week	
	Import	Export
Sunday (1)	.25	-
Monday	.17	.10
Tuesday	.16	.37
Wednesday	.10	.21
Thursday	.10	.22
Friday	.18	.10
Saturday (1)	.04	-
	1.00	1.00

(1) The container terminal does not operate on Saturdays and Sundays. Cars arriving on these days are unloaded on Monday.

Figure 2.1 Loaded Piggyback Flat Cars Forwarded from Terminal 'X'



The number of container rail cars forwarded as a percentage of the total cars forwarded in a one-week period is:

Peak Day	28%
Second Highest	23%
Third Highest	19%
Fourth Highest	16%
Fifth Highest	11%
Sixth Highest	3%
	100%

The number of container rail cars received on the peak day as a percentage of the total received during a one-week period could not be determined in the same manner. It was assumed that a maximum of 200 containers will arrive twice during the week and that the remainder of the traffic will arrive during the other five days.

2.5 Daily Intermodal Handlings - Peak Period 1984

By applying the factors discussed in Sections 2.2, 2.3 and 2.4 to the 1984 forecasted terminal handlings presented in Section 2.1, the daily handlings for 1984 were developed and are shown in Table 2.8.

Table 2.8 Intermodal Handlings - 1984 Peak Months

	Received By Rail								Forwarded By Rail						
	Trailers				Containers				Trailers			Containers			
Day of the Week	Plan I-III	Plan II		Total	Plan II		Domestic Total	Marine Import (1)	Plan I-III	Plan II	Total	Plan II Domestic	Plan II Marine	Marine Export	Total Marine
	LD	LD	MT(5)		LD	MT(5)									
Sunday	83	27	27	137	62	67	129	200	0	0	0	0	0	0	0
Monday	45	19	30	94	38	62	100	56	106	56	162	124	21	75	96
Tuesday	60	22	27	109	51	60	111	56	119	65	184	138	22	189	211
Wednesday	83	31	22	136	64	39	103	56	119	65	184	138	22	128	150
Thursday	80	29	16	125	58	30	88	56	119	66	185	138	22	155	177
Friday	91	24	22	137	52	47	99	200	125	69	194	147	24	108	132
Saturday	100	34	30	164	73	66	139	56	73	39	112	84	15	20	35
Total	542	186	174	902	398	371	769	680(3)	661	360	1,021	769	126	675 (4)	801

(1) This estimate is based upon the 80th percentile of the containers received, pro-rated to 1984 traffic levels, arriving on the two days on which peak is likely to occur. The remaining traffic is allocated over the other 5 days.

(2) This estimate is based upon the relating percentage of the week's traffic forwarded each day in descending order of daily volumes to probability that the peak will occur on a given day in the week.

(3) 680 handlings = 884 TEU; 476 - 20-foot and 204 - 40-foot

(4) 675 handlings = 877 TEU; 473 - 20-foot and 202 - 40-foot

(5) MT = empty trailers or containers

3. CYCLE TIMES FOR TRAILER AND CONTAINER HANDLING EQUIPMENT

3.1 Introduction

In reviewing the requirements of Terminal 'X' with the terminal operators, it was decided to continue to circus load trailers, to handle marine containers with the existing top-lifters, and to handle domestic containers and trailers with the new piggypackers. Once the rail cars are placed, the time required to strip a track and re-load it is a function of the type and number of machines available.

The equipment utilization was studied from October 1, 1979 to October 3, 1979 in connection with the one-week study of the terminal. The results of this study are discussed below.

3.2 Piggyback Ramp Loading Times

Observations were made of the ramp operation on October 1, 1979 and October 2, 1979 in order to determine the operating cycle times. Seven tractors were observed at various times although the maximum number was four at any one time.

Loading and unloading cycle time is defined as the interval from the time a tractor and/or tractor-trailer crosses from the ramp to a flat car, to the time it returns to the ramp. This cycle time is a function of the distance in car lengths from the end of the track. The data has been plotted and a linear regression made to develop equations for loading and unloading cycle times. Unusual delays are not included in this analysis.

Figures 2.2 and 2.3 show the average cycle time as a function of car lengths and the corresponding linear regressions.

The equation for the ramp loading cycle is:

$t = 0.70 + 0.23C$

where t = time in minutes
c = car lengths from the block end.

The total cycle time for 15 cars was 38.10 minutes. Delays in loading average 0.13 minutes per trailer or 1.95 minutes for 15 trailers. The total loading cycle time for 15 cars was 40.05 minutes, say 40 minutes.

The equation for the ramp unloading cycle is:

$t = 0.96 + 0.14c$

where t = time in minutes
c = car lengths from the block to end.

Figure 2.2 Ramp Loading Cycle Times

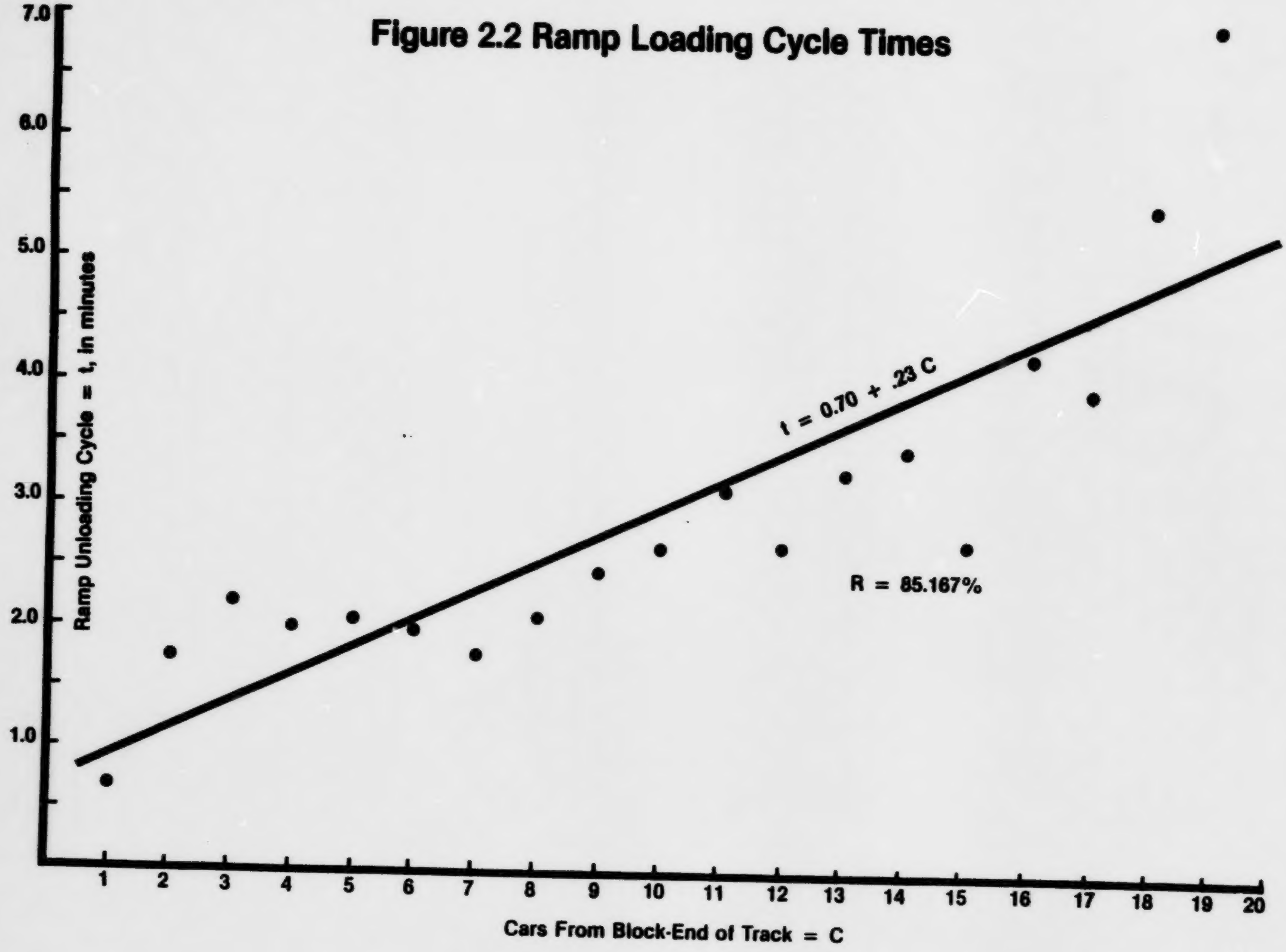
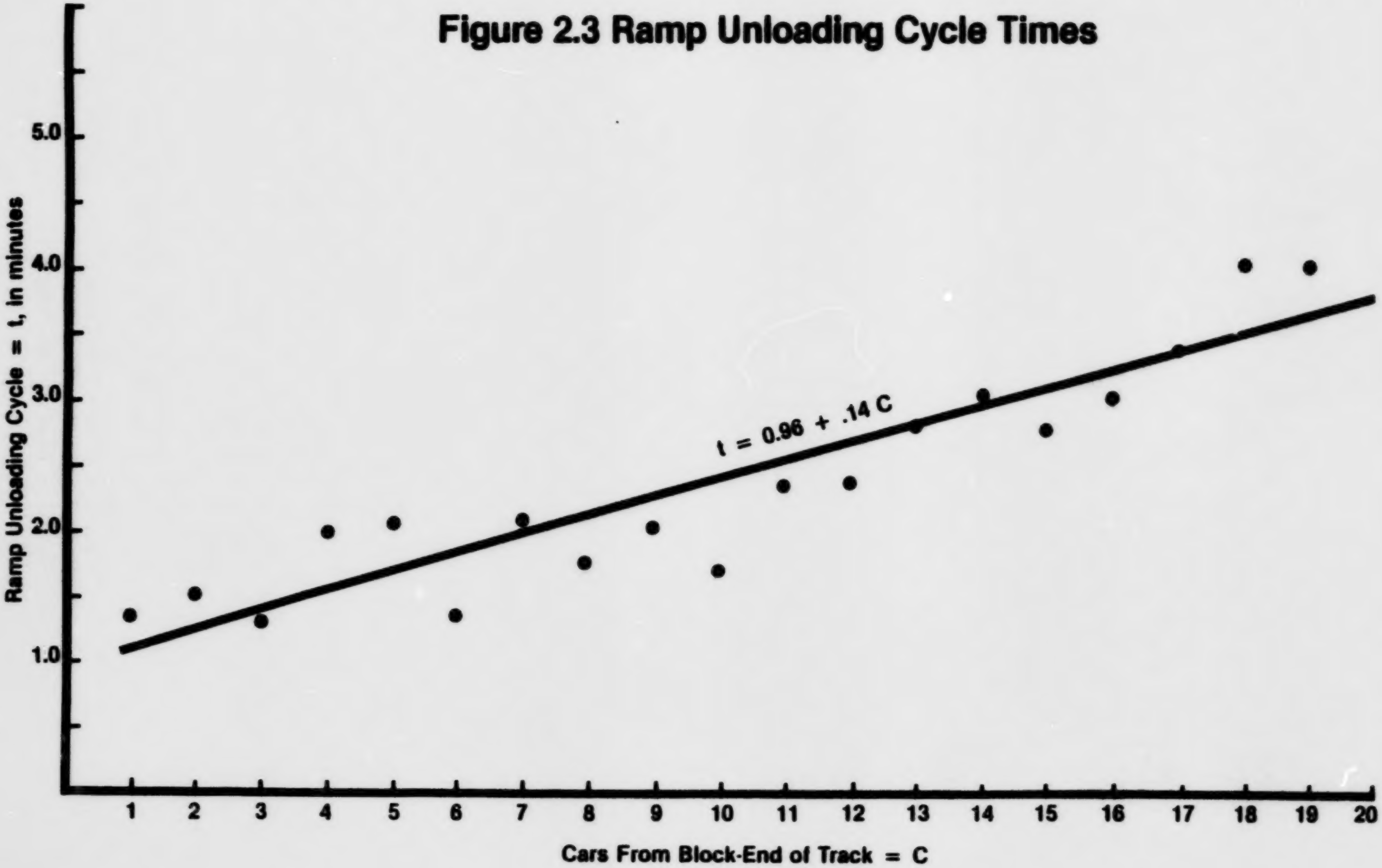


Figure 2.3 Ramp Unloading Cycle Times



The total cycle time for 15 cars was 31.20 minutes. Delays in unloading averaged 0.21 minutes per trailer, or 3.15 minutes for 15 trailers. The total unloading cycle time for 15 cars was 34.35 minutes, say 35 minutes.

The ground cycle time (the time from the tractor leaving the ramp until it returns) is a function of the distance to the point where a trailer is dropped or picked up. The ground cycle time was determined for all trailers observed without regard to specific trailer parking locations. The average ground cycle times were:

- trailers unloaded - 3.30 minutes/trailer;
- trailers loaded - 3.15 minutes/trailer.

A small sample of trailers returned empty to the terminal. The average ground cycle time for unloading these trailers was 2.89 minutes/trailer.

It was observed that the ramp tractors occasionally spent excessive time away from the ramp when loading or unloading trailers. The averages given above do not allow for these delays or for coffee breaks, lunch and personal time. Other activities not included are:

- break-down of the tractor;
- changing tractors;
- loading or unloading foreign knock-down flat cars (loading these cars took as long as 20 minutes and averaged 17.3 minutes);
- relocating trailers in the yard;
- waiting for the yard engine to switch the track.

The observations were made during the peak loading and unloading periods. An estimate of the other non-productive time (e.g. early quits, preparatory time) was not made.

3.3 Toplifter Cycle Times

Study personnel observed the two toplifters working on October 1-3, 1979. The toplifters and shifts observed were:

#1001 - Taylor - capacity 85,000 lbs.
- lifts 20' and 40' containers

Oct. 1 - 0700 - 1500 hours
Oct. 2 - 0700 - 1500 hours
Oct. 3 - 1600 - 2400 hours

#1010 - Taylor - capacity 95,000 lbs.
- lifts 20', 40', and 44' containers

Oct. 1 - 0700 - 1500 hours
Oct. 2 - 1500 - 2300 hours
Oct. 3 - 1500 - 2300 hours

3.3 Toplifter Cycle Times (continued)

Sixty-five minutes (13.5 percent) of an 8-hour shift was used for allowances such as coffee break, lunch and "quits". A further 15 minutes (3.1 percent) was used preparing the days work, obtaining instructions, pulling pins, etc. The remaining 83.4 percent of the shift was used in handling containers or running 'light' between container lifts. The major activities were as follows:

Activity	
. preparation and instructions	3.1%
. running light	35.6%
. lifting containers	
- rail car to ground	16.7%
- ground to chassis	16.0%
- chassis to rail car	5.5%
- chassis to ground	3.5%
. other	6.1%
. personal time	13.5%
	100.0%

The locations that a container was moved from and to was recorded as well as the cycle time. The terminal has four tracks dedicated to the handling of containers, numbered one (1) through four (4); and four storage areas, identified as A, B, C and L. Storage Area L refers to the seven container storage lines located to the south of the container terminal office. Figure 2.4 shows the layout of the terminal and the location of these storage lines and areas.

The cycle times for unloading containers were as follows:

Table 2.9 Time To Move Containers from Rail Cars to Ground

Track Number	Storage Area A	 B	 C	 L
	Time In Minutes			
1	1.28			
2	2.49	1.64		
3		2.02		
4	2.86	3.37		

Note: The times shown are averages of 10 or more observations.

The average time of all 129 observations was 2.24 minutes. The average time was 2.17 minutes for containers placed into Areas A-B-C and 3.08 minutes for containers placed into the Area L.

The cycle times for chassis to rail car or ground and from ground or rail car to chassis were as follows:

Table 2.10 · Lift Cycle Times of Toplifters 1001 and 1010

Cycle	1001	1010	Average
chassis - rail car	1.79 minutes	1.69 minutes	1.73 minutes
chassis - ground	1.55	2.12	1.85
ground - chassis	2.69	2.84	2.77

Note: The times shown are averages of 10 or more observations.

The small number of observations of:

- ground to rail cars;
- chassis to chassis;
- ground to ground;
- rail car to rail car;

precludes comment on the cycle times for these moves.

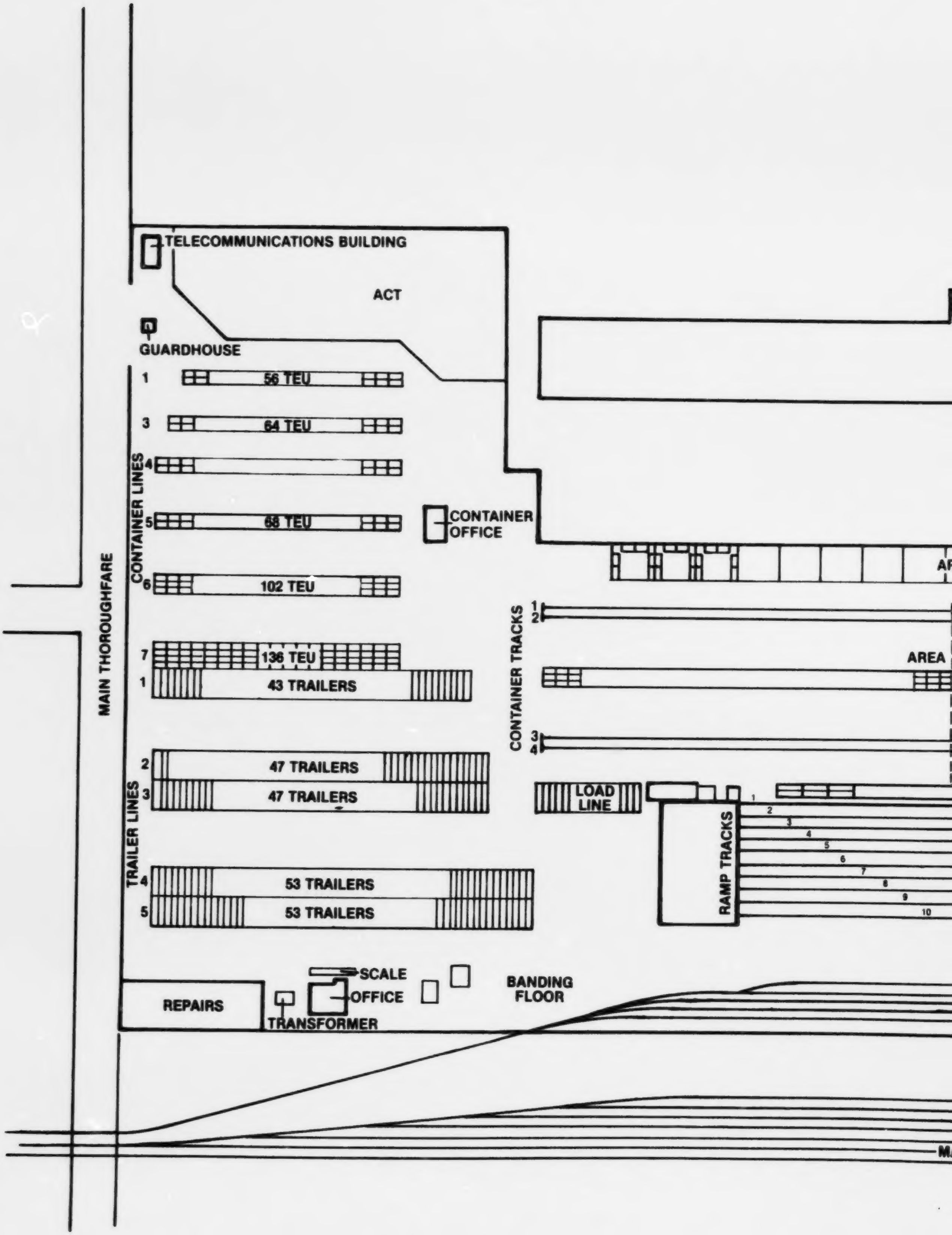
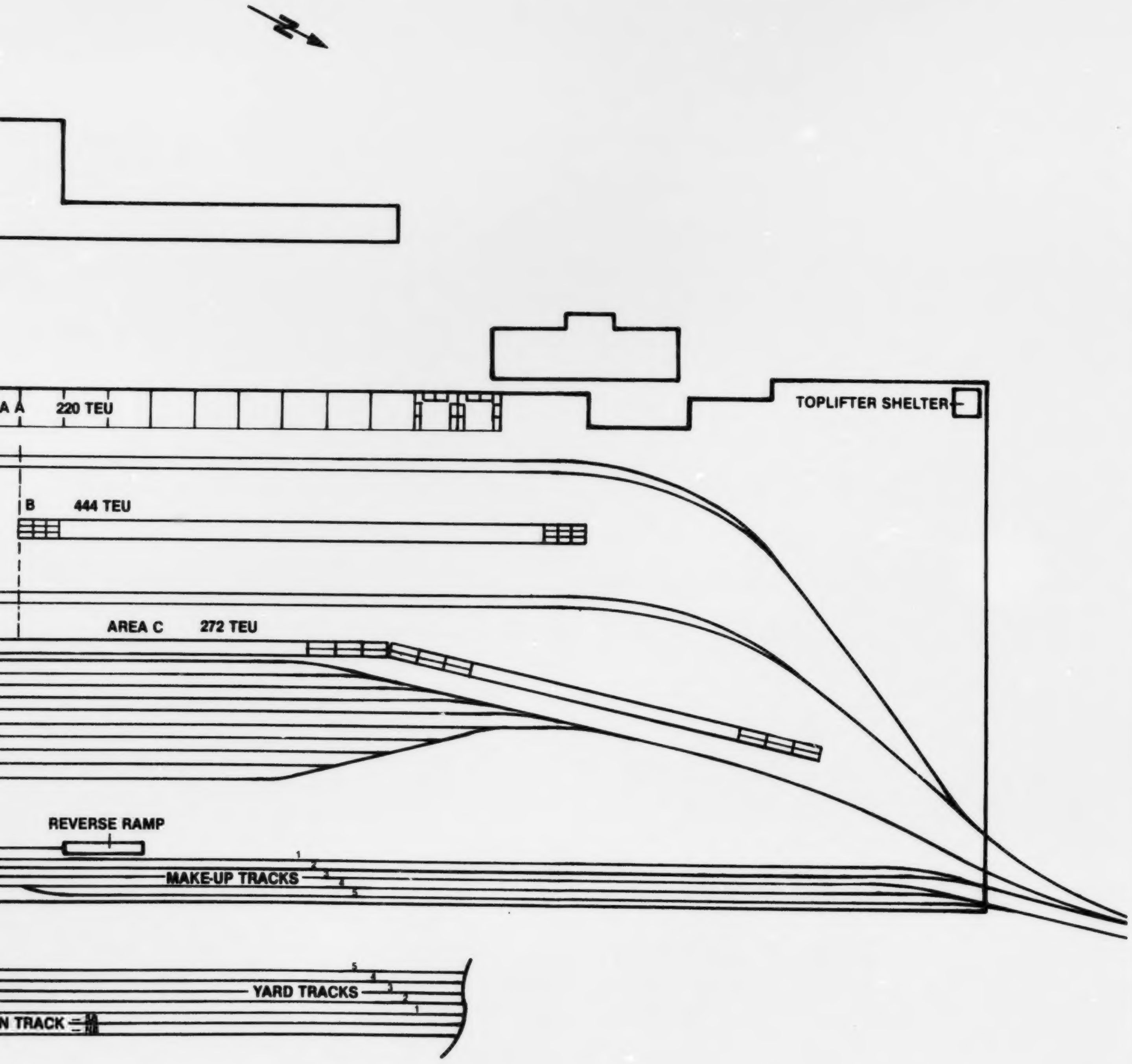

TELECOMMUNICATIONS BUILDING
ACT
GUARDHOUSE
MAIN THOROUGHFARE
CONTAINER LINES
1
56 TEU
3
64 TEU
4
5
68 TEU
6
102 TEU
7
136 TEU
CONTAINER OFFICE
TRAILER LINES
1
43 TRAILERS
2
47 TRAILERS
3
47 TRAILERS
4
53 TRAILERS
5
53 TRAILERS
CONTAINER TRACKS
1
2
3
4
AREA
AR
LOAD LINE
RAMP TRACKS
1
2
3
4
5
6
7
8
9
10
SCALE
OFFICE
REPAIRS
TRANSFORMER
BANDING FLOOR
M

Figure 2.4
Terminal 'X' Layout Plan


N
A
A
220 TEU
TOPLIFTER SHELTER
B
444 TEU
AREA C
272 TEU
REVERSE RAMP
1
2
MAKE-UP TRACKS
3
4
5
5
4
YARD TRACKS
3
2
1
N TRACK

Running light accounted for 35.6 percent of the time that the toplifters were used. Table 2.11 shows the cycle times where there were 10 or more observations. The average cycle times for light movements by the 1010 and 1001 units were 1.63 minutes and 2.06 minutes respectively.

Table 2.11 Cycle Times for Light Movements

Cycle Times In Minutes For Light Movements

	To							
	Area				Track			
From	A	B	C	L	1	2	3	4
A	2.06				0.98			2.54
B		1.29				1.34	1.20	2.19
C			1.40					
L				1.14				
1					1.19			
2								
3								
4								

Note: The times shown are averages of 10 or more observations.

3.4 Crane Cycle Times

3.4.1 CN Rail Standards

As Intermodal Services do not operate any cranes, cycle times could not be obtained for CP Rail owned and operated equipment. Cycle times were discussed with representatives of CN Rail with respect to their manual simulations. The cycle times observed by CN Rail are shown below:

Table 2.12 Piggyback Handling Operation Cycle Times

Machine	Location	Operation Cycle Time In Minutes Load Trailer On Flat Car	Operation Cycle Time In Minutes Unload Trailer From Flat Car
Le Tourneau SP-60	Norfolk & Western Calumet Yard Chicago	** 1.61 Min.	1.35 Min.
Piggypacker PC-90	Penn Central South Kearney New Jersey	1.96 Min.	1.49 Min.
Le Tourneau SP-90	Norfolk & Western Calumet Yard Chicago	** 1.94 Min.	1.65 Min.
Piggypacker F-70	Penn Central Englewood Chicago	2.39 Min.	1.67 Min.
Drott Travelift	Sante Fe Chicago	2.22 Min.	1.89 Min.
P.H. Rail Mounted Crane	Penn Central South Kearney New Jersey	2.39 Min.	2.17 Min.
Paceco	Penn Central 47th Street, Chicago	2.92 Min.	2.45 Min.
Circus System	Canadian National Turcot, Montreal	* 3.87 Min.	* 4.15 Min.

Source: CN Rail

* Includes travel time to or from storage
** Estimated from back-up information

3.4.2 Other Railroads

A.T. Kearney Inc. & Associates discussed cycle times in their reports on System Engineering for Intermodal Freight Systems prepared for the United States Department of Transportation. Typical cycle times extracted from this report are shown below:

Table 2.13 Loading Methods Cycle Times

Method	Time (minutes)	Comments
Circus	4.0	2 groundmen, 1 driver; ramp or deramp.
Crane	1.5-2.0	1 groundman, 1 operator; TOFC; lift-on or lift-off.
Crane	6.0-8.0	COFC - top-lift includes putting container on chassis.
Packer (TOFC/COFC)	3.0/trailer	1 groundman, 1 packer operator 1 hostler operator; lift-on or lift-off.
	6.0-8.0/ container	
Packer (COFC only)	3.0-4.0/ container	1 groundman, 1 packer operator, 1 hostler operator, lift-on or lift-off.

3.5 Relationship of Cycle Time to Manual Simulation

Cycle times are reported for the record only. The manual simulation of the terminal did not use these times directly, it relied instead on the terminal managers' experience to determine the time required to complete various activities. The cycle times developed above were used, however, as a guide in designing the initial terminal layout and as a check on the managers' subjective analysis.

4. GATE ACTIVITY

4.1 Introduction

All highway traffic arriving and leaving the terminal must pass through a security gate. A gate pass issued to the drivers is presented to the security guard who retains the pass and records the time of departure. During the study week, a record was kept to show loaded and empty trailers and containers leaving the terminal.

A gate entry record was also maintained showing the time in and whether the truck was handling a trailer, a container, an empty chassis or flatbed for containers; or running 'bob-tail'. Drivers were not stopped to determine if their trailers or containers were loaded or empty.

Containers handled into and out of the empty annex were also recorded and the times of arrival or departure shown.

It should be noted that the pattern for the morning of Monday, October 1, 1979 was not normal. The Teamsters Union conducted a strike vote on Sunday, September 30, 1979 and because of the possibility of a strike, there were a large number of trailers on hand at the terminal. The contract was accepted and the bulk of these trailers moved on Monday, October 1, 1979.

4.2 Gate Entry Record

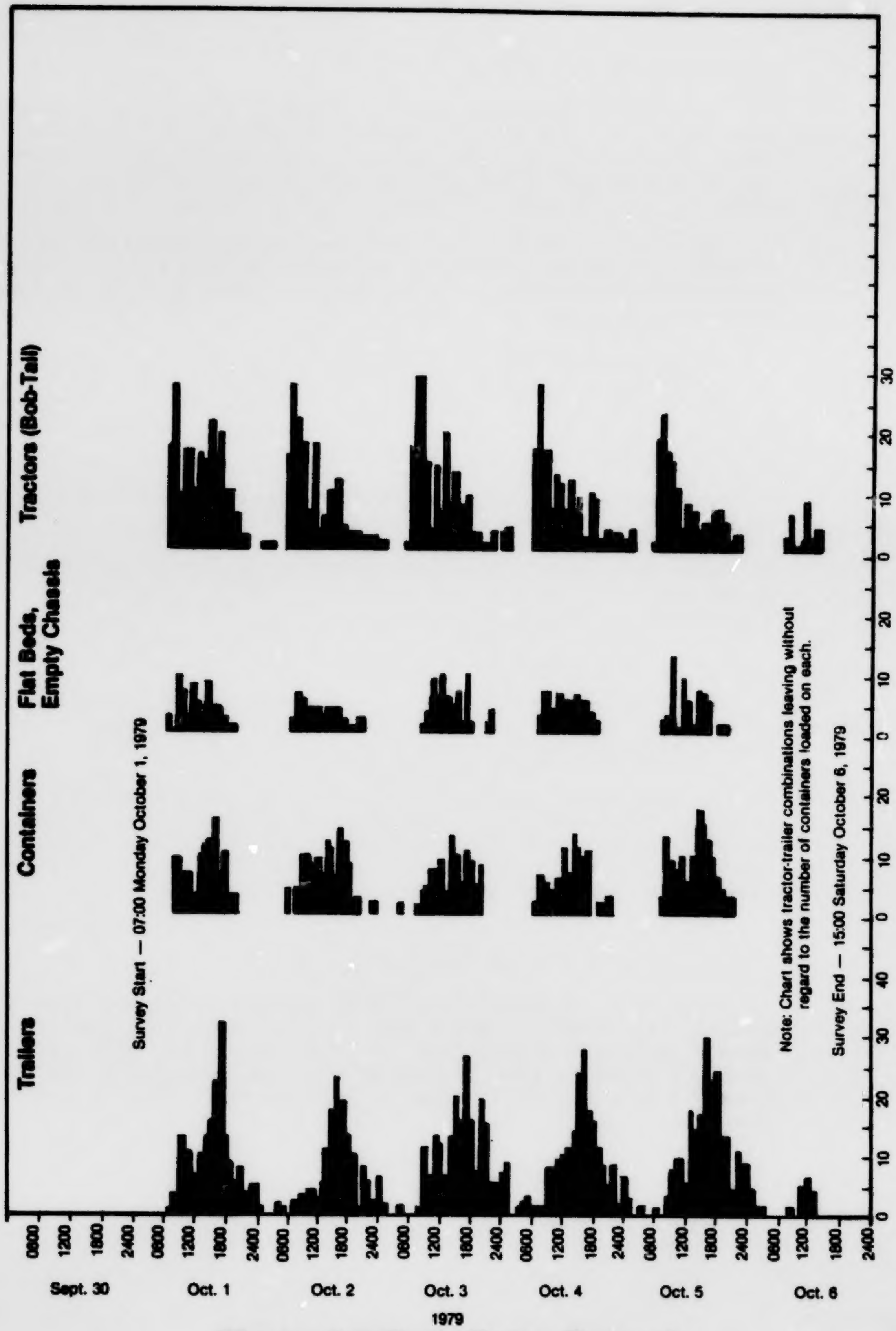
The peak period for trailer arrivals was from 1500 hours to 1800 hours. The rate of arrival of trailers during this period was as high as 32 per hour. During this three-hour period, approximately 70 trailers arrived.

The records show that up to 10 trailers per hour arrived from 2200 hours to 0200 hours. These trailers were probably delivered to connect with train 405.

Containers and flat beds or empty chassis for containers arrive uniformly during the day from 0900 hours to 1900 hours. The rate of arrival of containers was as high as 16 trucks per hour and the normal rate was 10 to 13 trucks per hour. The rate of arrival of flat beds and chassis was as high as 13 per hour and the normal rate was 6 to 10 trailers per hour.

'Bob-tail' tractors arrive from 0600 hours to 1000 hours. The large number arriving on Monday, October 1, 1979 reflected the large number of trailers on hand at the terminal.

A summary of the arrivals at the main terminal is shown in Figure 2.5.



Survey Start — 07:00 Monday October 1, 1979

Note: Chart shows tractor-trailer combinations leaving without regard to the number of containers loaded on each.

Survey End — 15:00 Saturday October 6, 1979

Figure 2.5 Gate Entry Record

4.3 Gate Exit Record

The majority of loaded trailers leave from 0700 hours to 1200 hours each day. The data for Monday, October 1, 1979 reflects the large inventory on hand that day. Loaded trailers were delivered over a greater portion of the day than for the other days of the week.

The effect of the late arrival of the train from Montreal is seen on October 3 when the first track was placed at 1200 hours. Trailers delivered during the afternoon of October 4 arrived on the container train that afternoon.

The departure of empty trailers is more or less uniform over the day. There was a high demand for trailers on Monday when as many as 17 trailers per hour left the terminal. Empty Plan II trailers were in short supply during the week and the number of empty trailers leaving may have been lower than normal.

Empty and loaded containers left the terminal more or less uniformly over the day from 0700 hours to 1800 hours.

Departures through the gate at the main terminal are shown in Figure 2.6.

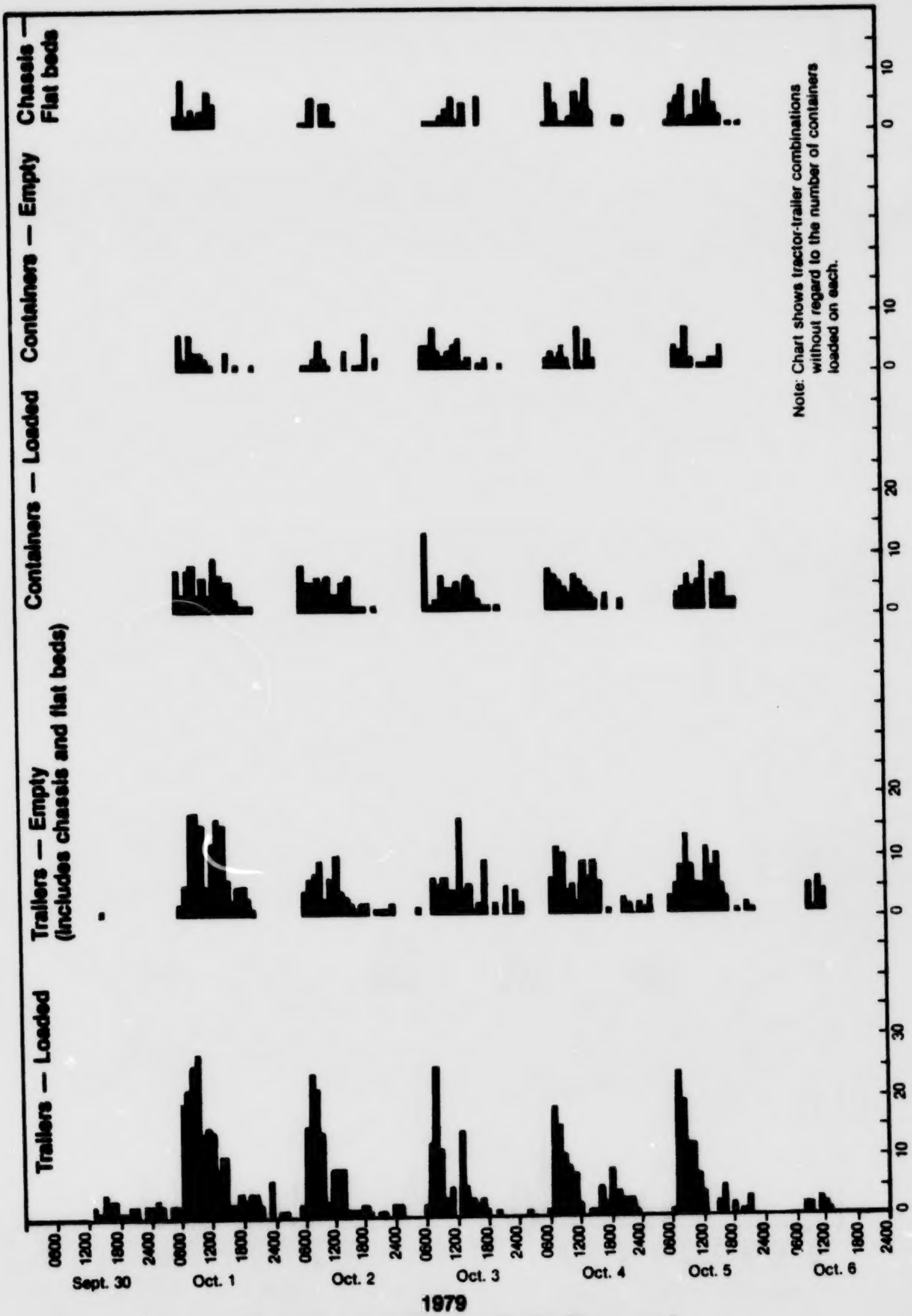
4.4 Empty Annex

The rate of containers arriving and departing from the empty annex varied from 5 to 10 per hour over the hours worked, 0800 to 1800 Monday to Friday.

The containers arriving and departing the empty annex are shown in Figure 2.7. Notice that the graph of the containers handled at the empty annex shows the actual number of containers, whereas the graphs for the main terminal show trucks arriving or leaving without regard to the number of containers on each truck.

4.5 Application to Manual Simulation

The arrival and departure patterns observed during the study week were maintained for the manual simulation at 1984 traffic levels. An average day was developed from the study week's activities and the frequency of arrivals was applied to the projected daily arrivals for the day simulated. This method of application is discussed in Section 8.3.



Note: Chart shows tractor-trailer combinations without regard to the number of containers loaded on each.

Figure 2.6 Gate Exit Record

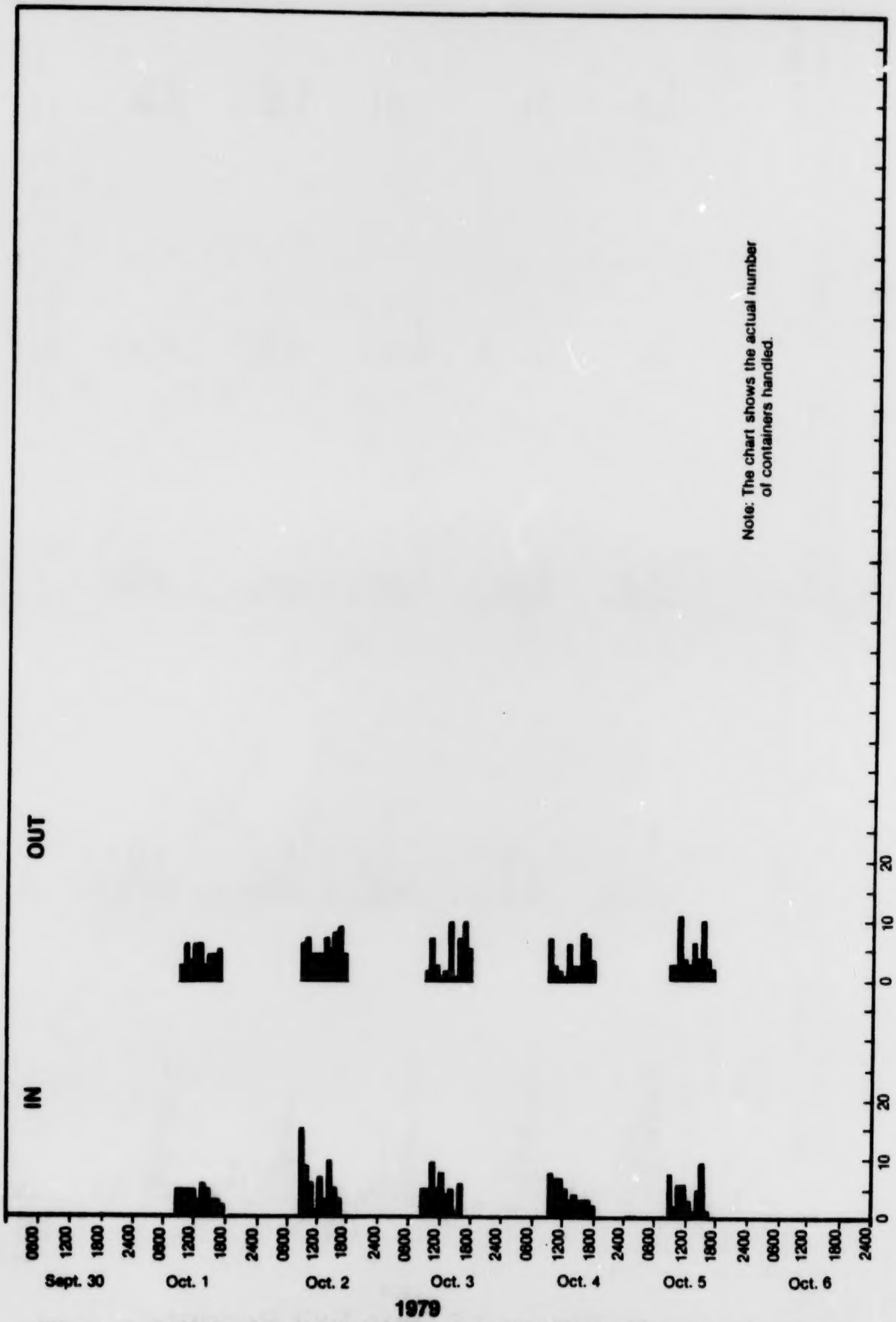


Figure 2.7 Arrivals and Departures at Empty Annex

5. DETERMINATION OF 1984 STORAGE AND TRACK REQUIREMENTS BY USING MANUAL SIMULATION

5.1 Factors Used to Determine Ground Storage Requirements

The ground storage requirements for loaded trailers and containers can be determined from the time spent in the terminal, i.e. from the arrival by rail to the departure by highway, and from the time spent between the arrival by highway and the departure by rail.

For a given storage area, the volume throughput can be increased by reducing this cycle time. This reduction may not always be possible as cycle time is related to:

- customer delivery requirements;
- normal working hours of the trucking industry;
- processing delays (e.g., customs clearance).

For the purpose of the study, it was assumed that there would be sufficient rail cars for the traffic forwarded so that traffic arriving by highway would be forwarded by rail on a same day basis. Also, empty trailers and containers arriving by rail were placed into storage until required for loading.

The cycle times observed during the study week were applied to the projected daily inbound handlings to determine the storage requirements.

The cycle times for Plan II trailers are shown in Table 2.14. These times were also applied to Domestic Containers as the traffic to be handled in Domestic Containers is similar to that now handled in Plan II trailers.

Table 2.14 Cycle Times for Plan II Trailers

Arrival by Rail - Delivered

Unloaded Monday to Friday

Delivered	- same day	57.8%
	- next day	28.9%
	- other	13.3%
		100.0%

Arrived on Weekend

Delivered	- September 30	4.8
	- October 1	89.0% %
	- October 2	4.8%
	- October 3	9.5%
		100.0%

Delivered - Made Empty

Delivered	- same day	76.1%
	- other	23.9%
		100.0%

Dispatch to Load - Departure by Rail

Delivered	- same day	37.8%
	- next day	29.2%
	- third day	9.0%
	- fourth day	5.2%
	- fifth day	6.0%
	- other	12.8%
		100.0%

The cycle times for Plan II trailers (also applied to Domestic Containers) were used to determine the storage requirements for loaded trailers or containers by dispatching the arrivals over the following days.

This table was also used to determine when an empty trailer or container was required based upon the loads arriving by highway each day and the time required to load trailers. Empty trailers were provided first from the loaded trailers delivered and made empty; a then from the empty trailers or containers held in storage at the terminal. The cycle times for Plan I-III trailers are shown below:

Table 2.15 Cycle Times for Plan I-III Trailers

Arrived by Rail Monday to Friday

Delivered -	same day	79%
	next day	13%
	third day	4%
	fourth day	2%
	fifth day	1%
	later	1%
		100%

Arrived by Rail on Weekend

Delivered -	same day	24%
	following Monday	56%
	following Tuesday	11%
	later	9%
		100%

The cycle times for marine containers are shown below:

Table 2.16 Cycle Times for Marine Containers

	Import	Empty		Export	
Time Interval	Arrival-Delivery	Delivery-Return	Return-Out Empty	Out Empty-Return	Return Shipped
	%	%	%	%	%
same day	8.1	21.8	17.2	8.0	71.0
next day	16.6	36.9	17.8	35.1	12.1
third day	11.8	11.1	7.3	10.2	3.2
fourth day	6.8	5.8	5.2	11.7	4.2
fifth day	6.4	3.9	9.9	5.1	3.7
sixth day	5.4	3.4	11.9	2.2	5.3
seventh day	10.5	5.8	4.6	6.6	-
eigth day	2.4	1.9	7.3	2.9	-
ninth day	7.4	2.4	2.0	1.5	-
other	24.6	7.0	16.8	16.7	0.5
	100.0	100.0	100.0	100.0	100.0

The ground storage requirements for trailers and containers were determined by manual simulation and by recording the inventory of trailers and containers on hand for the next day at the end of each day's activity. The total ground storage area required must provide enough space for grounding trailers and containers arriving on a given day. The model assumed that all empty marine containers would be stored off-site, probably at an enlarged empty annex.

On September 29, 1979 there were 681 empty containers at the empty annex and 214 at the main terminal, a total of 895. This figure is three (3) times the number of loaded containers on hand on the same date. It also represents 1.87 times the number of containers shipped during the study week from the main terminal.

The distribution of 20-foot and 40-foot empty containers on September 29, 1979 was:

Location	20'	40'	Total
Main Terminal	100	114	214
Empty Annex	570	111	681
	670	225	895

The ratio of 20-foot empties to 40-foot empties was approximately 75:25 (compared to the 70:30 assumed for loaded marine containers handled).

5.2 Factors Used to Determine Track Length Requirements

The number of rail flat cars arriving at and departing from the terminal was determined from the data shown in Table 2.8.

For this study, it was assumed that trailers are loaded one per flat car and that the outside length of the cars is 57 feet 7 inches. Domestic Containers are loaded two per flat car having an outside length of 94 feet 8 inches. Marine containers are handled in cars which are 49 feet 4 inches or 86 feet 7 inches long. For the purpose of this study it was assumed that:

- the ratio of 49-foot cars to 86-foot cars is 40:60 (the ratio projected to 1984 reflects recent car acquisitions and the attrition of the present fleet);
- 95 percent of the slots available for marine containers will be used;
- the ratio of 20-foot containers to 40-foot containers in 1984 will be the same as in 1979, i.e. 70:30.

5.3 Storage and Track Requirements

Storage and track requirements have been projected by manual simulation to 1984 based upon the data developed in Table 2.8 and in Sections 5.1 and 5.2. The results of the simulation are shown in:

- Table 2.17 Trailers;
- Table 2.18 Domestic Containers - Plan II;
- Table 2.19 Marine Containers.

Table 2.17 Trailer Storage and Track Requirements 1984 Peak Month

	Day of the Week							
Trailers Received by Rail	Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Total
Plan II Trailers								
Loads arriving	27	19	22	31	29	24	34	186
Empties arriving	27	30	27	22	16	22	30	174
Sub-total	54	49	49	53	45	46	64	360
Plan I-III Trailers								
Loads arriving	83	45	60	83	80	91	100	542
Total received	137	94	109	136	125	137	164	902
Trailers Forwarded by Rail								
Plan II	0	56	65	65	66	69	39	360
Plan I-III	0	106	119	119	119	125	73	661
Total forwarded	0	162	184	184	185	194	112	1,021
Storage Required								
Plan II loads	74	46	21	16	16	14	48	
Plan II empties	57	62	69	63	40	0	30	
Plan I-III	204	80	35	19	20	21	121	
Total Storage	335	188	125	98	76	35	199	
Dispatch								
Plan II loads delivered	0	48	47	36	29	26	0	186
Plan II empties placed for loading	0	67	67	67	70	89	0	360
- ex-loads made empty	0	42	47	39	31	27	0	186
- ex-yard	0	25	20	28	39	62	0	174
Plan II trailers delivered ex-yard	0	73	67	64	68	88	0	360
Plan II loads picked-up	0	56	65	65	66	69	39	360
Rail Cars								
Rail cars received (1)	154	111	126	153	142	154	181	1,021
Rail cars forwarded	0	162	184	184	185	194(2)	112	1,021
Rail cars on-hand	223	172	114	83	40	0	69	

(1) The model assumes that 17 empty rail cars per day arrive for Plan I-III traffic.

(2) The track length required is equivalent to 194 rail cars.

	Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Total
Plan I-III Trailers Released	0	169	95	109	79	90	0	542

Table 2.18 Domestic Container (Plan II) Storage and Track Requirements - 1984 Peak Month

	Day of the Week							
	Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Total
Domestic Containers Received by Rail								
Loads arriving	62	38	51	64	58	52	73	398
Empties arriving	67	62	60	39	30	47	66	371
Total	129	100	111	103	88	99	139	769
Domestic Containers Forwarded by Rail								
Loads forwarded	0	124	138	138	138	147	84	769
Storage Required								
Loads	164	109	70	44	32	29	102	
Empties	133	138	146	128	67	0	66	
Total	297	247	216	172	99	29	168	
Dispatch								
Loads delivered	0	93	90	90	70	55	0	398
Empties placed for loading	0	141	143	147	166	172	0	769
- ex-loads made empty	0	84	91	90	75	58	0	398
- ex-yard	0	57	52	57	91	114	0	371
Containers delivered ex-yard	0	150	142	147	161	169	0	769
Containers picked-up	0	124	138	138	138	147	84	769
Rail Cars								
Rail cars received	65	50	56	52	44	50	69	386
Rail cars forwarded	0	62	69	69	69	74(1)	43	386
Rail cars on-hand	91	79	66	49	24	0	26	

(1) The track length required is equivalent to 74 rail cars (two Domestic Containers per car, 147 divided by 2 = 74 cars).

Table 2.19 Marine Container Storage and Track Requirements - 1984 Peak Month

	Day of the Week							
	Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Total
Marine Containers Received By Rail								
Import handlings	200	56	56	56	56	200	56	680
Marine Containers Forwarded By Rail								
Export handlings	0	75	189	128	155	108	20	675
Plan II marine	0	21	22	22	22	24	15	126
Total	0	96	211	150	177	132	35	801
Storage Required								
Total containers stored (end-of-day)	931	837	727	651	587	675	731	
20 ft. (70%)	652	586	509	456	412	473	512	
40 ft. (30%)	279	251	218	195	175	202	219	
TEU	1,210	1,088	945	846	762	877	950	
Containers Interchanged								
Import-private trucker	0	120	133	106	96	90	0	545
Import	0	30	33	26	24	22	0	135
Sub-Total	0	150	166	132	120	112	0	680
Export	0	75	189	128	155	108	20	675
Total containers interchanged	0	225	355	260	275	220	20	1,355
Plan II Marine	0	21	22	22	22	24	15	126
Rail Cars (1)								
Train length received (ft.)	6,130	1,716	1,716	1,716	1,716	6,130	1,716	
Train length forwarded (ft.)	0	2,942	(2) 6,467	4,598	5,425	4,056	1,073	
Rail cars on-hand	136	130	73	42	0	38	53	

(1) Ratio of train length to handlings is 30.65 feet per container as follows:

n = number of handlings
0.7n = 20' containers; 0.3n = 40' containers
TEU = 0.7n + 2 (0.3n)
20' rail car slots = TEU divided by 0.95
rail cars = 20' slots divided by 3.2
rail cars = $\frac{1.3n}{(0.95)(3.2)}$: 40 percent are 49'-4"; 60 percent are 86'-7"

$$\text{Total length} = \frac{1.3n}{(0.95)(3.2)} [(0.4)(49.33) + (0.6)(86.58)] = 30.65n$$

(2) Track length required is 6,467 feet.

6. STORAGE AND TRACK REQUIREMENTS 1980 TO 1984

6.1 Terminal Requirements

The data developed in Section 5 for the year 1984 was used to determine the peak day handlings, trackage requirements and storage requirements.

Table 2.1 shows the projected terminal handlings by year from 1980 to 1984.

The 1984 terminal requirements have been pro-rated over the years from 1980 to 1984 to determine the track length and storage requirements in each of these years. The results of these calculations are shown in Table 2.20.

Table 2.20 Terminal Handlings - Peak Months 1980 - 1984

Trailers (See Table 2.17)

	1980	1981	1982	1983	1984
Annual handlings	82,958	82,120	79,786	74,456	72,528
Peak day	222	220	213	199	194 (1)
Track length (feet)	12,784	12,668	12,265	11,469	11,171 (2)
Storage (units)	383	379	369	344	335 (3)

(1) Friday trailers forwarded by rail
(2) 194 rail cars @ 57 feet 7 inches
(3) Sunday midnight, includes 57 empty Plan II trailers.

Domestics (See Table 2.18)

	1980	1981	1982	1983	1984
Annual handlings	4,500	17,400	32,000	50,000	66,000
Peak day	10	39	71	111	147 (1)
Track length (feet)	474	1,894	3,408	5,301	7,005 (2)
Storage (units)-loads	11	43	80	124	164
-empties	9	35	64	101	133
-empty chassis	3	13	24	38	50 (3)
-Total	23	91	168	263	347 (4)

(1) Friday domestic containers forwarded by rail
(2) 147 containers require 74 cars @ 94 feet 8 inches
(3) These estimates are very rough because there is little experience upon which to base an analysis.
(4) Sunday midnight, includes 133 empties.

Marine (See Table 2.19)

	1980	1981	1982	1983	1984
Annual handlings	65,757	69,046	71,116	73,250	75,447
Peak day	200	200	200	205	211 (1)
Track length	6,130	6,130	6,130	6,283	6,467 (2)
Storage (TEU)	1,056	1,107	1,141	1,175	1,210 (3)
Loaded empty storage (TEU)	1,120	1,175	1,211	1,247	1,285 (4)

(1) Tuesday marine containers forwarded by rail (includes Plan II marine)
(2) See equation on Table 2.19
(3) Sunday midnight
(4) All empties assumed to be stored off-site

7. SHORT TERM RECOMMENDATIONS FOR INITIAL DESIGN STUDY

7.1 1984 Track Requirements

The data shown in Table 2.20 indicates that by 1984 the trackage required at the terminal will be as follows:

	Length	% of Total
Trailers	11,171 feet	45.3
Domestic Containers	7,005 feet	28.4
Marine Containers	6,467 feet	26.3
	24,643 feet	100.0

The introduction of piggypackers will permit the handling of trailers and Domestic Containers on the same tracks. This alternative was considered; however, it was found that the circus loading of trailers made the most efficient use of the land available. Therefore, the modifications proposed for the initial design study included tracks for the side-loading of Domestic Containers, but retained the circus loading ramps and tracks as well.

7.2 Existing Trackage

The present track capacity of the terminal consists of:

- four (4) container tracks with a total holding capacity of 66 - 94-foot 8-inch cars (6,300 feet);
- ten (10) piggyback tracks with a total holding capacity of 183 - 57-foot 7-inch cars (10,538 feet);
- five (5) make-up tracks with a total holding capacity of 146 - 55-foot cars;
- five (5) yard tracks in the rail yard with a total holding capacity of 262 - 55-foot cars;
- one (1) reverse ramp track with a holding capacity of 7 - 55-foot cars;

The existing trackage is adequate for the 1984 projected volume of trailer and marine container traffic, but there will be insufficient trackage for Domestic Containers.

7.3 Possible Solution for the Shortage of Trackage

Three possible solutions can be considered in order to alleviate the problems associated with the forecast shortage of trackage.

7.3.1 Changes in Operating Practices

The effect of the peaks involved with export container handlings can be reduced by:

- revising the service standards to permit containers to be left for the next day's loading;
- revising the "cut-off" times while still guaranteeing that export containers will arrive at the port in time for scheduled sailings;
- loading seven days a week.

The peaks in import container handlings can be further reduced by:

- holding cars out for the next days' unloading (the model assumes that the peak import handlings are equivalent to the traffic available on one ship);
- unloading seven days a week, 24 hours per day (a must in any event as the model does not accumulate traffic arriving Saturday and Sunday for Monday's handling).

Eastern Canada traffic could also be relocated to a new terminal.

7.3.2 Increase in the Efficiency of Switching

The existing tracks could be turned over more than once per day. It takes 20-25 minutes to pull cars out of one track (including coupling at the crossing and pulling out into CTC territory) and setting the cars over into the make-up tracks. An additional 20-25 minutes is required to fill a track with cars.

Assuming that the loading and unloading operations cannot continue while the tracks are switched, switching operations reduce the time available for loading by two (2) hours per additional switch. This increase may require more lifting equipment. These problems can be alleviated by:

- scheduling arrivals and departures more frequently to correspond with tracking turnovers;
- lengthening the switching tail track;
- constructing a grade separation at the main thoroughfare.

7.3.3 Trackage Expansion

Trackage lengths can be expanded by:

- constructing additional container flat car handling tracks. These tracks could be built parallel to the existing tracks and overhead cranes could be used for loading and unloading the cars.
- expanding the terminal onto the property to the west and by constructing additional trackage.

7.4 Recommended Short-term Modifications to Expand Trackage Capacity

The short-term modifications recommended for the terminal are as discussed below.

7.4.1 Container Tracks

Marine containers are to be handled on Container Tracks 1, 2 and 3. Container Track 4 is to be released for handling Domestic Containers.

7.4.2 Ramp Tracks

Ramp Tracks 2 to 7 inclusive will remain dedicated to trailer traffic. Track 1 can be extended northward to provide a track for Domestic Containers. Presently Track 1 is of limited use for side-loading as 300 feet of this track is bordered by the electrical facilities required for the refrigerated containers.

7.4.3 New Tracks

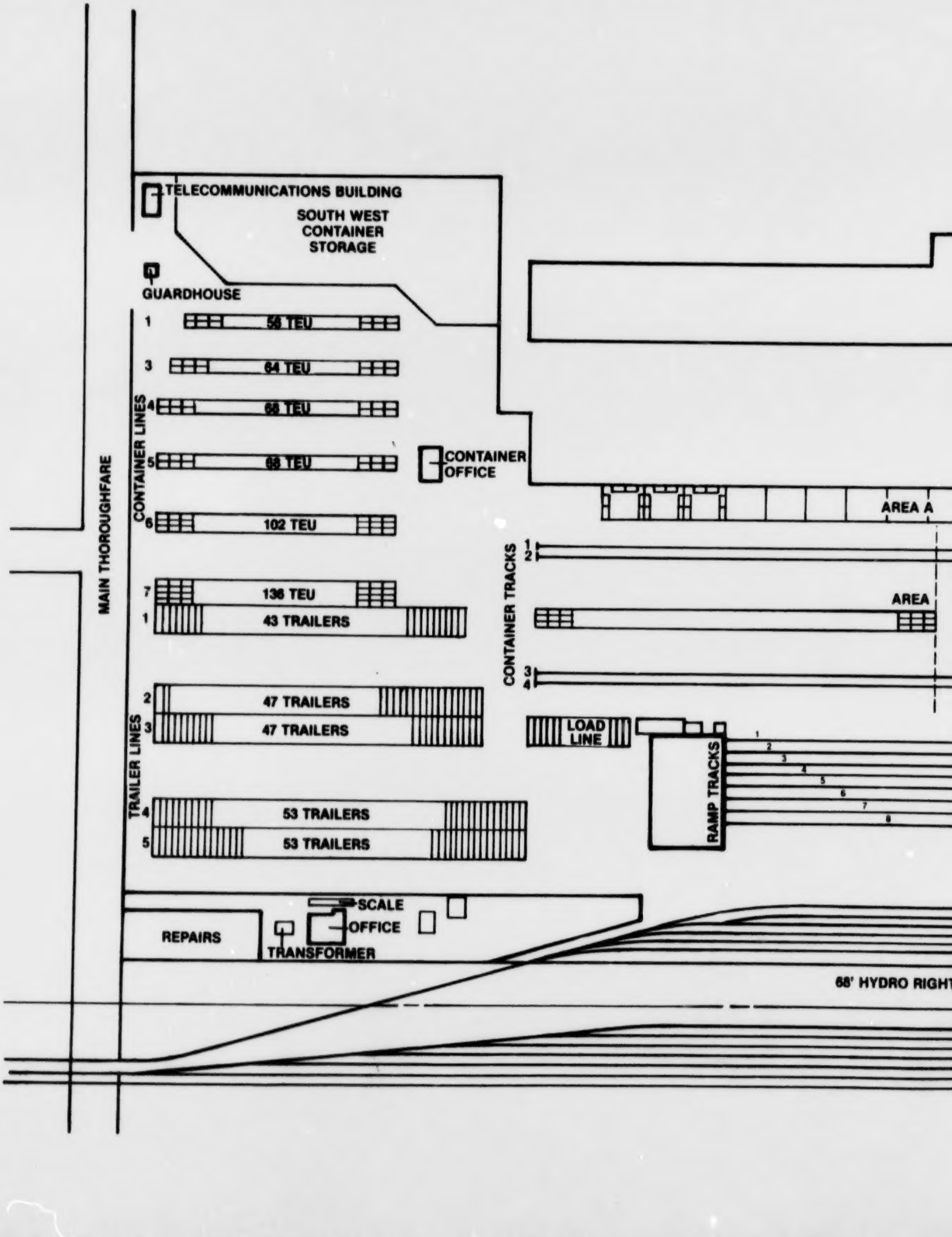
The existing Ramp Tracks 9 and 10 are to be taken up. The existing Ramp Track 8 is to be extended northward to tie directly into the ramp track lead.

The existing reverse ramp track is also to be extended northward and connected to Make-up Track 1. This extended track will be designated as Track 10.

An additional track will be built parallel to Track 10 which will tie directly into the ramp lead and will be designated as New Track 9.

Ramp Track 8 and New Track 9 can be used for Domestic Containers.

The track arrangements as a result of these modifications are shown in Figure 2.8.


TELECOMMUNICATIONS BUILDING
SOUTH WEST CONTAINER STORAGE
GUARDHOUSE
MAIN THOROUGHFARE
CONTAINER LINES
1
58 TEU
3
64 TEU
4
68 TEU
5
68 TEU
6
102 TEU
7
136 TEU
CONTAINER OFFICE
AREA A
CONTAINER TRACKS
1
2
AREA
3
4
TRAILER LINES
1
43 TRAILERS
2
47 TRAILERS
3
47 TRAILERS
4
53 TRAILERS
5
53 TRAILERS
LOAD LINE
RAMP TRACKS
1
2
3
4
5
6
7
8
SCALE
OFFICE
REPAIRS
TRANSFORMER
68' HYDRO RIGHT

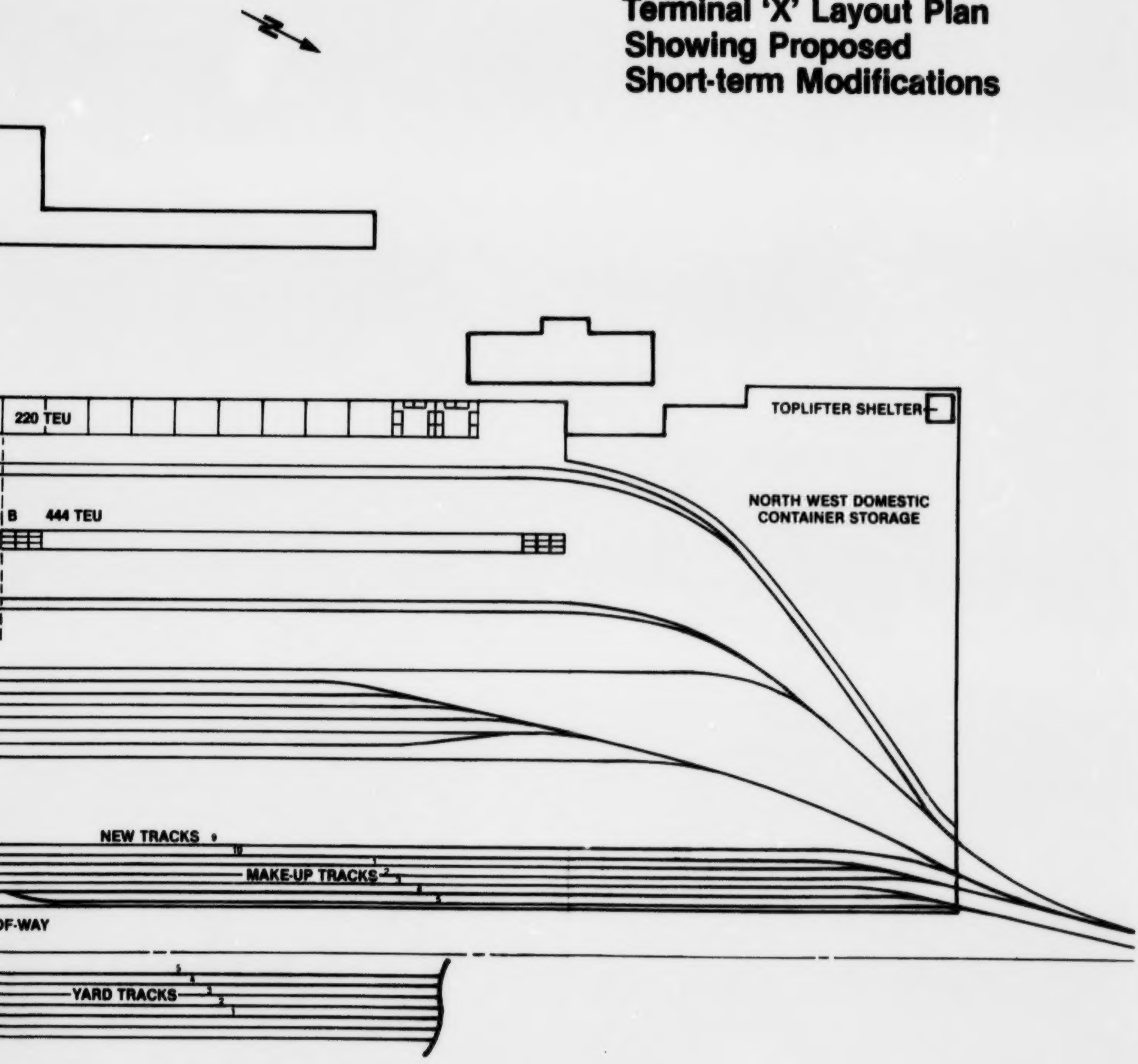

N
220 TEU
B
444 TEU
TOPLIFTER SHELTER
NORTH WEST DOMESTIC CONTAINER STORAGE
NEW TRACKS
9
10
MAKE-UP TRACKS
1
2
3
4
5
OF-WAY
YARD TRACKS
5
4
3
2
1

Figure 2.8
Terminal 'X' Layout Plan
Showing Proposed
Short-term Modifications

The lengths of track after modification are as follows:

Table 2.21 Track Lengths - Initial Design

Track	Clear Length (feet)	Primary Use
Container 1	1500	marine containers
Container 2	1500	marine containers
Container 3	1650	marine containers
Container 4	1650	Domestic Containers
Ramp 1	1870	trailers and Domestic Containers
Ramp 2	900	trailers
Ramp 3	1000	trailers
Ramp 4	1100	trailers
Ramp 5	1200	trailers
Ramp 6	1200	trailers
Ramp 7	1100	trailers
Ramp 8	1400	Domestic Containers
New 9	1350	Domestic Containers
Extended 10	1250	make-up yard

7.5 Present Utilization of Ground Storage

The existing parking layout at the terminal provides storage for 383 trailers and 1312 TEU of containers (stored 2-high).

The storage capacity for trailers is directly related to the number of ground trailer parking spaces. The number of ground slots for containers is readily determined but the total capacity is a function of the stacking height. Also, capacity can be increased by increasing the width of the storage lines. The criteria for heights and widths is established by the terminal operating management.

Tables 2.22 and 2.23 provide the details of the present storage capacities for trailers and containers at the terminal (see Figure 2.4 for the location of the various lines and areas.)

Table 2.22 Terminal Storage Capacity - Containers

Location		Design Criteria	Ground Slot TEU	Total TEU	20-Foot Containers	40-Foot Containers
Area	A	containers in U-shape, 6 slots/U one space left empty.	120	220	220	-
	B	line 3 wide X 2 high	222	444	-	222
	C	line 2 wide X 2 high	136	272	24	124
Line	1	line 2 wide X 2 high	28	56	56	-
	3	line 2 wide X 2 high	32	64	64	-
	4	line 2 wide X 2 high	34	68	68	-
	5	line 2 wide X 2 high	34	68	68	-
	6	line 3 wide X 2 high	51	102	-	51
	7	line 4 wide X 2 high	68	136	136	-
ACT		storage for 20' ACT Containers	-	-	40	-
		Totals	725	1,430		

Table 2.23 Terminal Storage Capacity - Trailers

Location	Parking Spaces
Line 1	43
Line 2	47
Line 3	47
Line 4	53
Line 5	53
Repairs	20
Banding floor	13
Loading line	15
Area along track 10	20
Area north of reverse ramp	72
Total	383

7.6 Recommended Short-term Modifications to Expand Storage Capacity

The use of piggypackers between Container Track 4 and Ramp Track 1 will eliminate the use of Area C for storing marine containers. Similarly, their use between Ramp Track 8 and New Track 9 will preclude the parking of trailers in the area along Ramp Track 10 (to be removed) and the area north of the existing reverse ramp (also to be removed).

The effect of this reduction will be that empty 40-foot marine containers will no longer be stored in the main yard. It has been assumed that all empty marine containers will be held at the empty annex.

The areas paved in 1979 and 1980 can be used for storing marine containers and empty domestic containers. The practical storage capacity of the terminal will then be as shown below.

Table 2.24 Storage Capacity - Revised Terminal

Area	Capacity	Type
A	220 TEU	marine
B	444 TEU	marine
1	56 TEU	marine
3	64 TEU	marine
4	68 TEU	marine
5	68 TEU	marine
6	102 TEU	marine
7	136 TEU	marine
SW	208 TEU	marine
TOTAL	1366	
NW	166 units	empty domestic containers - 2 high
Lines 1 - 5	243 units	trailers or Domestic Containers on chassis

7.7 Summary - Recommended Short-term Physical Changes

The changes in track layouts and operating practices recommended in Sections 7.3 and 7.4 and illustrated in Figure 2.8 will provide sufficient trackage for the successful operation of the term through 1984. The comparison of the 1984 track length requirements for peak months versus terminal capacities is as follows:

	Present Layout	Required 1980 (Table 2.20)	Required 1984 (Table 2.20)	Modified Layout (Table 2.21)
	(1)	(2)	(3)	(4)
Trailers	10,538 ft.	12,784 ft.	11,171 ft.	6,500 ft.
Marine Containers	6,300 ft.	6,130 ft.	6,467 ft.	4,650 ft.
Domestic Containers	______	474 ft.	7,005 ft.	6,270 ft.
	16,838 ft.	19,388 ft.	24,643 ft.	17,420 ft.
Peak month track turnover (2)÷(1) and (3)÷(4)	1.15	1.41		

The terminal can still operate in 1984 with the track changes proposed if the track turnover is improved. This improvement is possible with the changes in operating practices recommended.

The changes in layouts and operating practices will also affect the requirements for storage areas. The implementation of the recommendations presented in Sections 7.5 and 7.6 will result in a serious shortage of land area for the storage of trailers and containers.

The comparison of the capacities versus the requirements is presented below:

	Present Layout (Tables 2.22,2.23)	Required 1980 (Table 2.20)	Required 1984 (Table 2.20)	Modified Layout (Table 2.24)
Loaded Marines (TEU)	1,430	1,055	1,210	1,366
Empty Marines (TEU)		1,120	1,285	-
Trailers (units)	383	383	335	243
Loaded Domestics (units)		11	164	
Empty Chassis (units)		3	50	
Empty Domestics (units)		9	133	166

The serious shortage of land for Domestic Containers and trailers must be alleviated in the near future by the acquisition of land in the vicinity. The storage of the empty Domestic Containers at the empty annex as well as the empty marine containers will provide an additional 150 units of storage for trailers and loaded Domestic Containers on chassis in the NW area.

The question of land acquisition and trackage requirements is discussed further in Section 9.

8. MANUAL SIMULATION

8.1 Background

From the outset, one of the purposes of the Intermodal Terminal Design Study was to develop a means of evaluating the capacity of an intermodal terminal given alternate design layouts and operating procedures. It was felt that this evaluation could be done by a computer-assisted simulation technique and a number of existing packaged programs were investigated to see if they could be applied to this terminal. Annex I, II and III relate to work done outside this project concerning computer-assisted simulation techniques.

Annex I is a summary of the work performed by Systems Control Inc. for the FRA (Federal Railroad Administration, U.S. Department of Transportation). This report entitled "Intermodal Freight Terminal Simulation - Requirements Definition" studies the potential applications of an intermodal freight terminal simulator as well as the features required by the simulator to serve the outlined applications.

Appendices II and III relate to the actual simulator models developed in Britain. Although not directly applied to truck/rail intermodal terminals, both the "Mersey Docks and Harbour Company Container Berth Simulation" and the "British Rail Freightliner Systems" were evaluated in order to determine their suitability as frameworks for the development of a simulation model of truck/rail terminals.

A complex computer simulation technique is not necessary to study one terminal. The manual methods used herein to determine the daily activities at future traffic levels are easy to apply, providing that the cycle times, etc. are known or can be determined beforehand. Activities on an hourly basis can be projected using statistical analysis techniques and a work program can be developed for the terminal accordingly.

With respect to the operation of equipment within the terminal, a simulation may be made using time and motion measurement techniques. Alternatively, a manual simulation of the terminal may be made by having the terminal managers operate the terminal at the projected traffic levels given an existing or modified rail - roadway - storage infra-structure.

A manual simulation approach was used to test the initial design of a revised terminal.

8.2 Estimate of Peak Week Traffic

The total demand in the terminal for a one-week period was determined as described in Section 2.

Based upon this demand, modifications to the terminal were then proposed and discussed with the terminal and system management and a plan was developed. A manual simulation of this revised terminal at 1984 traffic levels was then made for a Friday of the peak week. Friday was selected as it was the busiest weekday and had a container train (505) arriving on that day.

Although Friday was not a critical day for storage (the analysis showed Sunday to be the critical day), it was the best day to simulate as the gate activity on week-end days is at a minimum and the storage requirements increase as traffic is unloaded from the rail cars.

8.3 Estimate of Hourly Traffic

The arrival and departure data shown in Figures 2.5 and 2.6 was used to develop a factor for hourly arrivals and departures as a percentage of the daily arrivals and departures. These factors were then applied to the projected 1984 volumes and an average inter-arrival/inter-departure time was calculated for the peak hours.

Arrivals and departures to the nearest minute were then determined from the average inter-arrival/inter-departure times by applying standardized exponential random number tables to the average times. This procedure simulates arrivals in accordance with a Poisson process.

All arrivals and departures of trailers and containers (Domestic and marine) were determined in this manner for a typical Friday. A destination was then designated for arrivals by highway based upon the traffic pattern illustrated in Table 2.3. All marine containers were assumed to be destined to Montreal and east.

An empty/load status was assigned to the units leaving the terminal and trailers were further designated by plan.

Consists were developed for traffic arriving by rail based upon the existing train marshalling patterns and traffic origins shown in Table 2.2.

The storage requirements at 0001 Friday were determined from Tables 2.17, 2.18, and 2.19. Empty rail cars on hand were also determined.

8.4 Terminal Activity for a Typical Friday

The traffic volumes, activities, and trailers, containers and rail cars on hand for the day simulated were as follows:

8.4.1 Storage

Trailers

Plan I-III - nil
Plan II - 16 loads
- 40 empties

Total trailers = 56

Domestic Containers

Plan II - 32 loads
- 67 empties

Total Domestic Containers = 99

Marine Containers

40' import - 175
20' import - 417

Total marine containers = 762 TEU

All empty marine containers were assumed to be stored off-site.

8.4.2 Rail Cars On-hand

Trailer flats - 40
Domestic container flats - 24 (All required Friday)
Marine container flats - Nil

8.4.3 Loads at Customers' Docks

Trailers

Plan II - 7

(All made empty Friday)

Domestic Containers

Plan II - 15

8.4.4 Arrivals by Rail - by Origin

	Total	Eastern Canada	Western Canada
Trailers			
Plan I - III	91	47	44
Plan II - loads	24	12	12
Plan II - empties	22	9	13
Total	137	68	69
Domestic Containers			
loads	52	28	24
empties	47	19	28
Total	99	47	52
Marine Containers			
20'	140	140	
40'	60	60	
Total	200	200	

8.4.5 Arrivals by Rail - by Train

	Western Canada (0500 hours)	Eastern Canada (0600 hours)	Container Train	Total
Trailers				
Plan I - III	44	47		91
Plan II - loads	12	12		24
Plan II - empties	13	9		22
Domestic Containers				
loads	24	28		52
empties	28	19		47
Marine Containers				
20'		10	130	140
40'		3	57	60

8.4.6 Delivery

Types of Traffic	From Storage	From Friday Arrivals	Total
Trailers			
Plan I - III	-	91	91
Plan II - loads	12	14	26
Plan II - empties	40	22	62*

*Note: Also 27 made empty at customers' docks to be spotted for re-loading.

Types of Traffic	From Storage	From Friday Arrivals	Total
Domestic Containers			
Plan II - loads	25	30	55
Plan II - empties	67	47	114*

*Note: Also 58 made empty at customers' docks to be spotted for re-loading.

Types of Traffic	From Storage	From Friday Arrivals	Total
Marine Containers			
Private Truckers	77	13	90
Intermodal (20%)	19	3	22
Total	96 (67-20') (29-40')	16 (11-20') (5-40')	112 (78-20') (34-40')

8.4.7 Arrivals by Highway/Forwarded by Rail

	Total	Eastern Canada	Western Canada
Trailers			
Plan I - III	125	61	64
Plan II	69	24	45
Total	194	85	109
Domestic Containers			
Marine Containers			
20'	76	76	-
40'	32	32	-
Total	108	108	-

8.5 The Manual Simulation Model

A plan of the terminal to a scale of 1 inch = 100 feet was obtained, corrected as required, and an enlargement made to a scale of 1 inch = 40 feet. Track changes to conform with the initial design were then made on the enlarged plan and this plan was used as a model of the terminal.

The plan was mounted on a magnetic board and magnetic cards were cut to scale to represent rail cars, trailers and containers. The terminal was pre-loaded to represent units and rail cars on hand at 0300 hours Friday. The day's activity ended with the dispatch of the last outbound train and started prior to the arrival of the first inbound train.

Sufficient magnetic cards were cut to represent all units arriving by rail, rail cars on hand and units on hand. It was also necessary to prepare magnetic cards for some arrivals by highway in the event that the units departing the terminal were fewer than those arriving by highway.

The manual simulation was made from January 12 to January 15, 1981. The day's activity was simulated in detail on an hour by hour basis and records were kept of the activities of:

. road engines;

. yard engines;

. ramp tractors;

. piggypackers;

. toplifters.

During the simulation, each operation was studied separately and a clock ran to ensure that all activities stayed "in-step."

The individual participants were responsible for monitoring the activities relating to their normal work at the terminal. The times developed in Section 7 were used as a check of the activity durations.

8.6 Results of the Manual Simulation

Records were kept of all activity in the terminal from 0300 hours of the typical Friday to 0300 hours on Saturday. A summary was prepared at the end of each hour and the day's activities were shown on graphs or tables as appropriate.

8.6.1 Train Arrival Transfer Activities

Trailers arriving by rail and loaded and empty trailers on the ground are shown in Figure 2.9. In the simulation there were 16 empty and 40 loaded trailers in the terminal and the first cut of 15 trailers on flat cars (TOFC) was placed at 0510 hours. Figure 2.9 shows the number of trailers on the ground (i.e. starting inventory and trailers unloaded less trailers delivered) and the number of TOFC at any one time. The last trailer was unloaded at 1100 hours and the absolute maximum number of trailers on the ground was 105 at 0700 hours.

Domestic Containers arriving by rail and loaded and empty Domestic Containers on the ground are shown in Figure 2.10. The starting inventory was 32 loads and 67 empties and the maximum number on the ground was 130 units at 0800 hours. The first car with a Domestic Container was placed at 0530 hours and the first Domestic Container was grounded at 1130 hours.

Marine containers arriving by rail and on the ground are shown in Figure 2.11. A total of 16 TEU arrived on the train from Eastern Canada and were placed at 0755 hours. The balance arrived on the container train and were placed after 1645 hours.

It should be noted that at the end of the simulation there were still 42 - 20-foot and 21 - 40-foot marine containers on the make-up tracks. These containers were assumed to be left for unloading on the following day, Saturday.

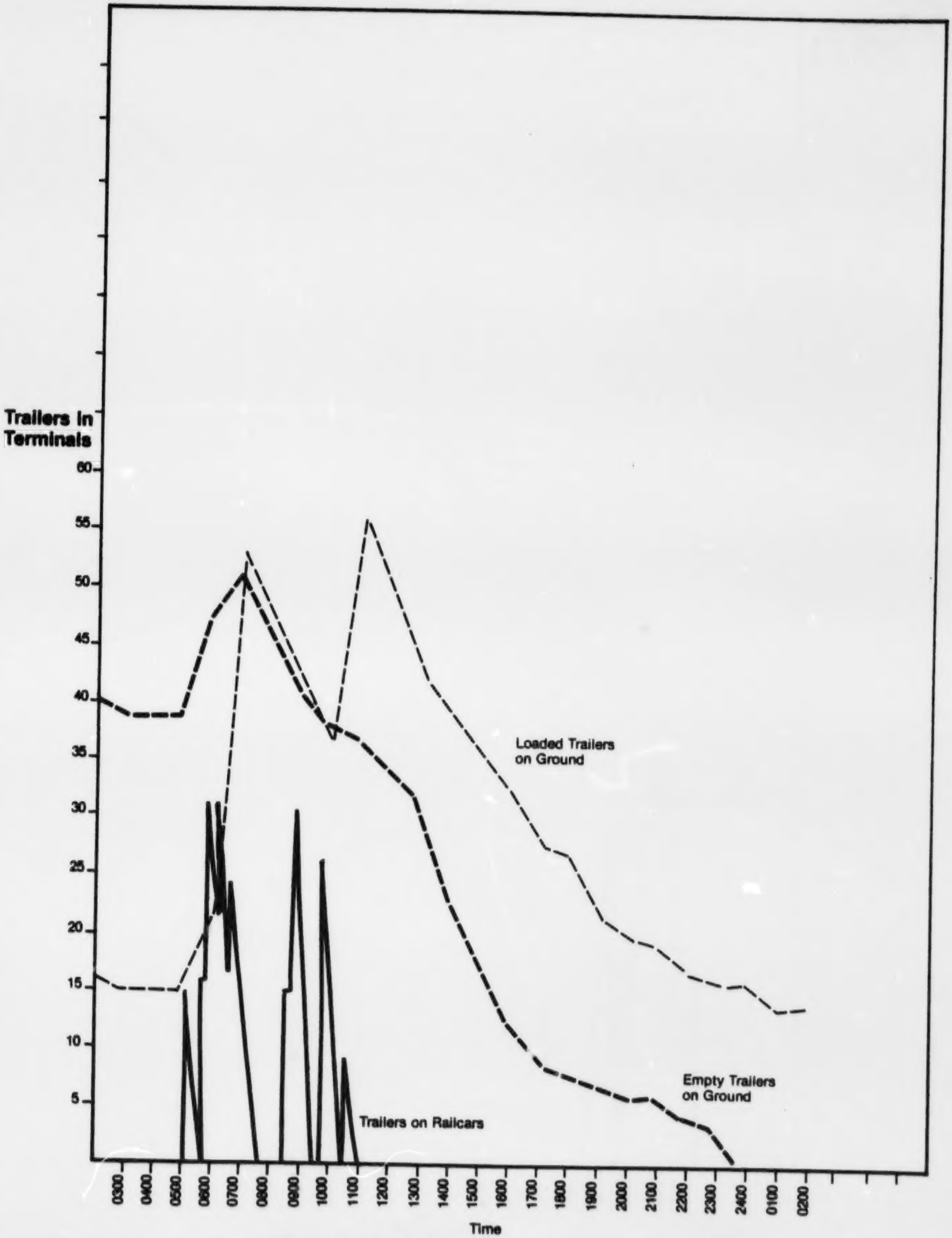


Figure 2.9 Trailers Arriving by Rail

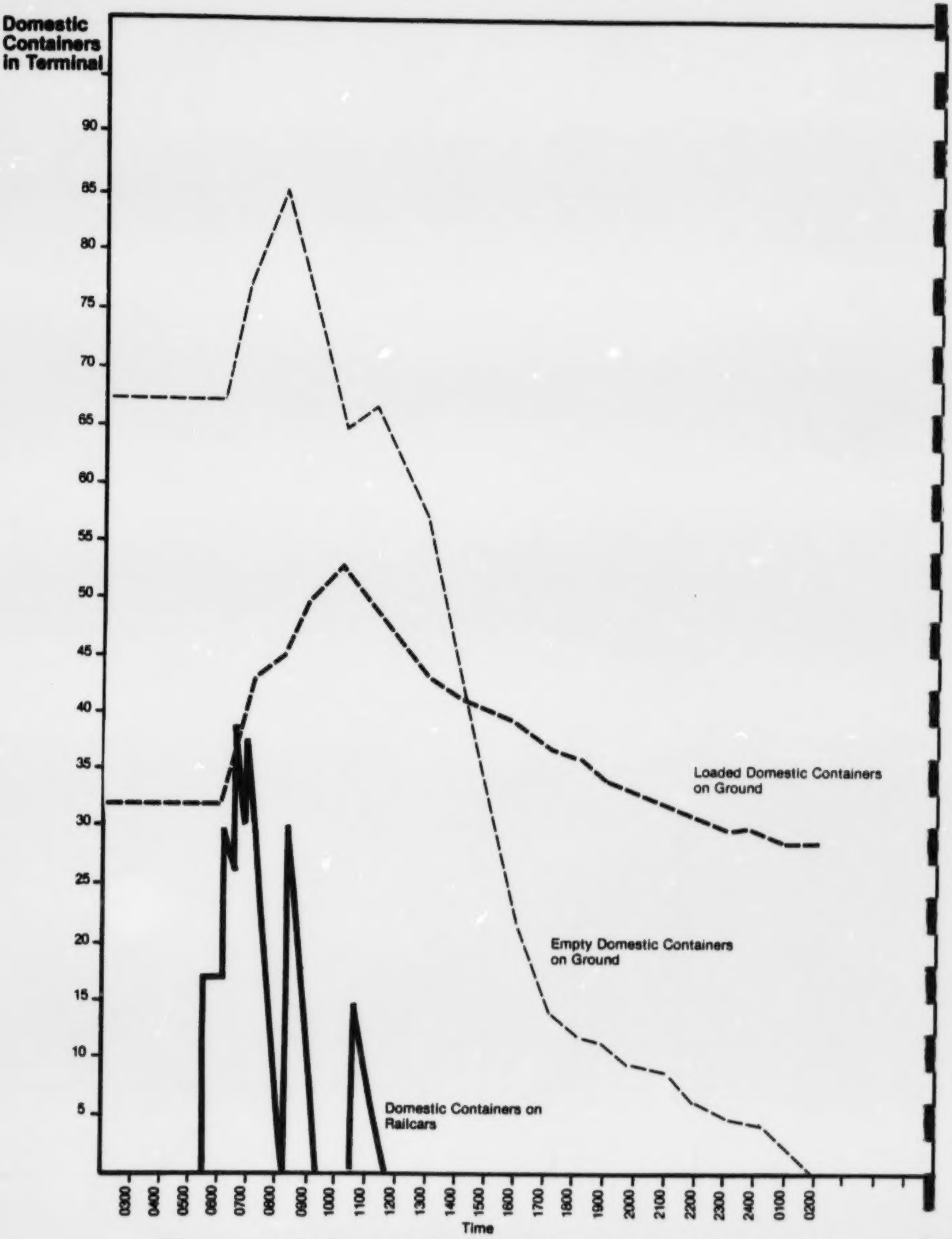
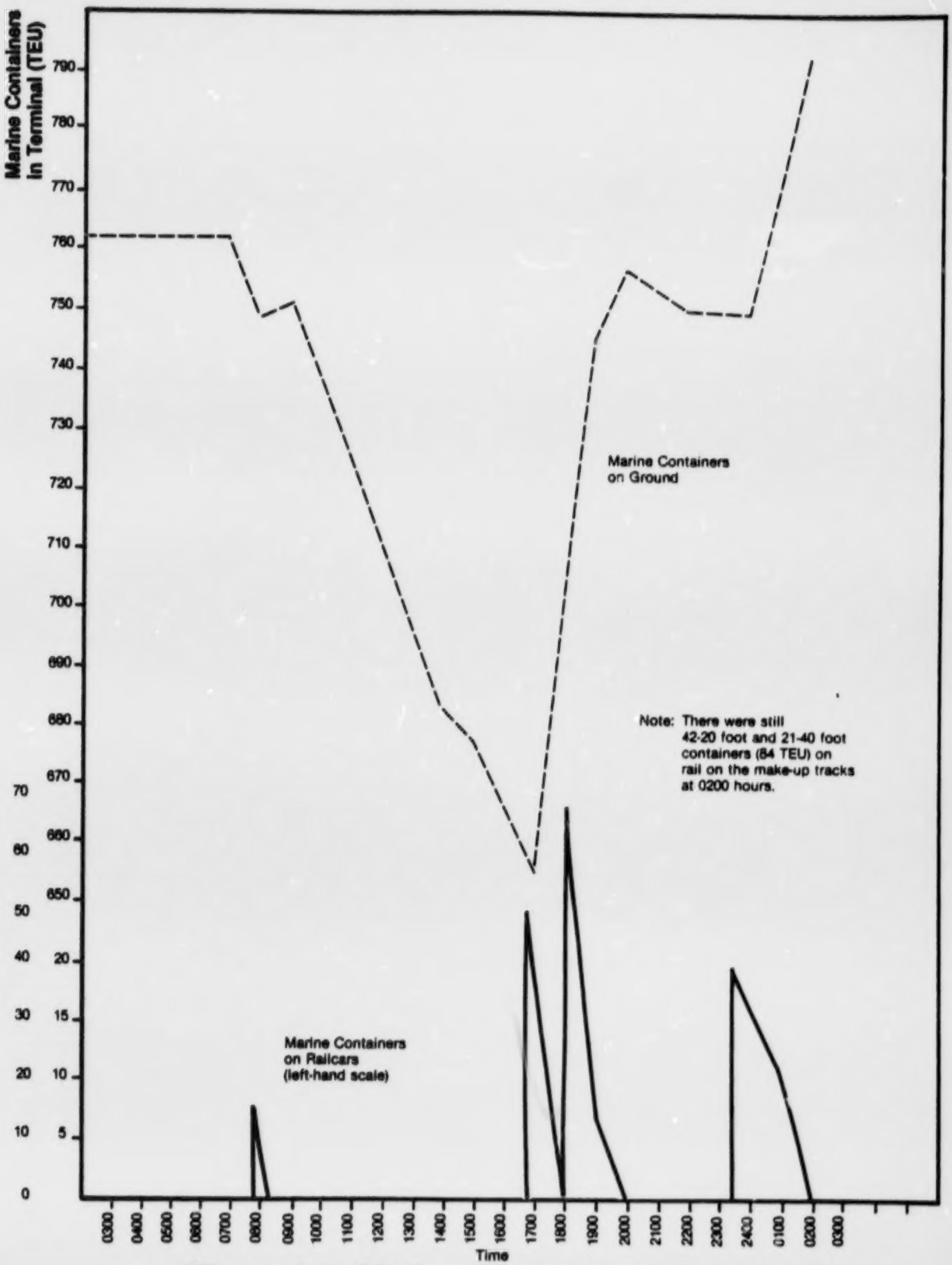


Figure 2.10 Domestic Containers Arriving by Rail



Note: There were still 42-20 foot and 21-40 foot containers (84 TEU) on rail on the make-up tracks at 0200 hours.

Figure 2.11 Marine Containers Arriving by Rail

8.6.2 Train Departure Transfer Activities

Figure 2.12 shows the number of trailers arriving at the terminal for loading on rail cars. The first trailer arrived at 0300 hours and the maximum number in the loading line was 35 at 1700 hours. The first trailer was loaded at 1000 hours and cuts of cars were pulled at 1130 hours, 1530 hours, 1830 hours, 1845 hours, 2030 hours, 2040 hours, 0010 hours and 0110 hours.

At the end of the simulation, there were 48 trailers left in the terminal on rail cars and 26 left on the ground. There were only 5 empty rail cars left in the terminal at the end of the simulation.

The domestic containers departing by rail are shown in Figure 2.13. Loading was carried out continuously from 1000 hours and cars were pulled at 2040 hours, 2330 hours and 0110 hours. The maximum of Domestic Containers in the loading line was 35 at 1900 hours.

At the end of the simulation there were 55 Domestic Containers on the rail cars and 15 on the ground. The last Domestic Container arriving by rail was unloaded at 1130 hours. After 1800 hours, fewer chassis were required for delivery of Domestic Containers than became available from the transfer of Domestic Containers to rail cars. Also in operating the terminal, the domestic containers arriving on rail cars remained on the rail cars until a chassis was made available from a departing Domestic Container.

The marine containers departing by rail are shown in Figure 2.14. A large number of containers were grounded as there were insufficient rail cars available for loading from 1400 hours to 1715 hours. This action was precipitated by the late arrival of the container train.

It is important to have a supply of rail cars on hand at the terminal for marine containers. This feature must be considered in any simulation of the operation and a balance of nil is not acceptable at any time.

At the end of the simulation, there were 40 TEU's on rail cars and none on the ground; however, most of the day's loadings were still in the make-up tracks and in the main rail yard at the end of the simulation.

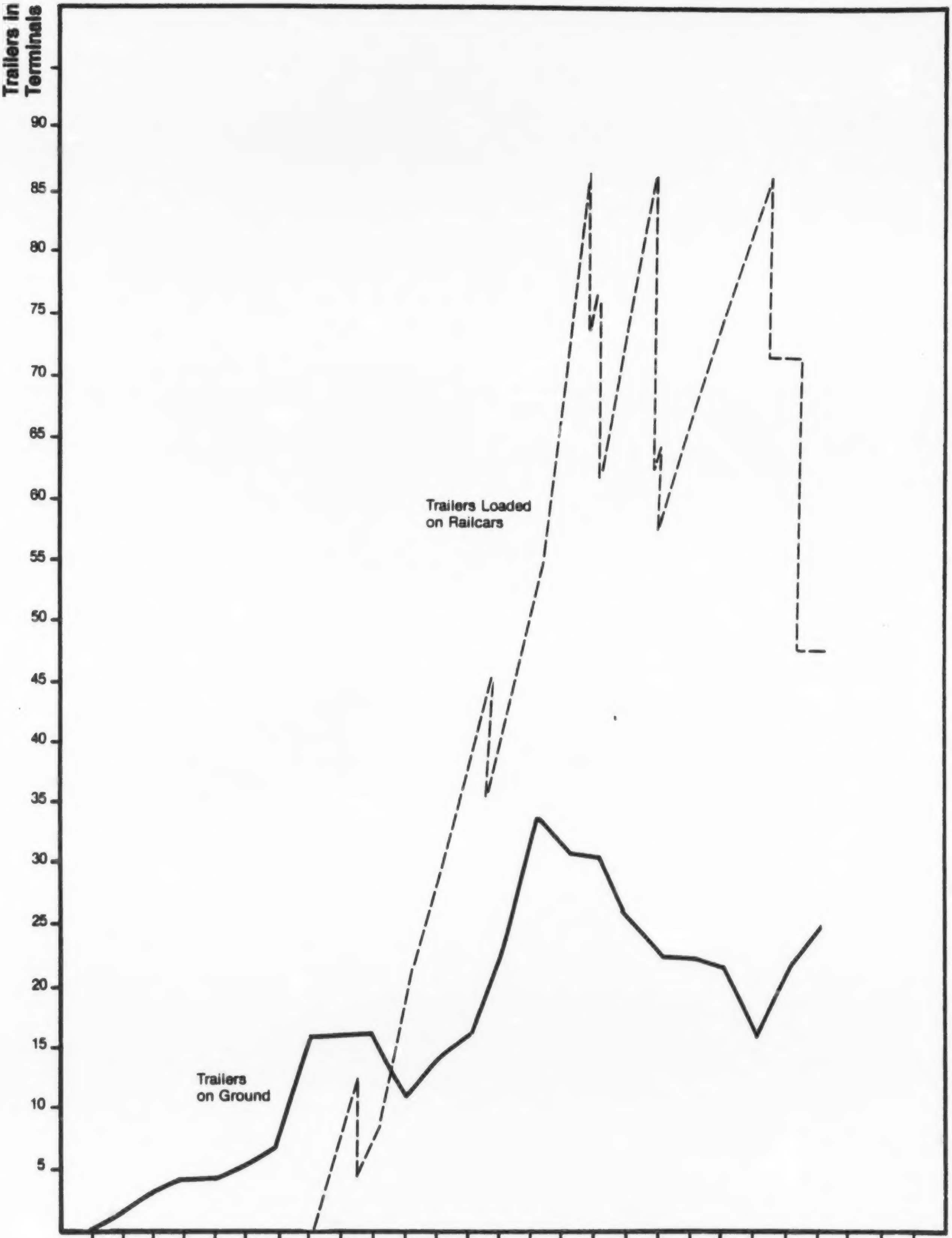


Figure 2.12 Trailers Departing by Rail

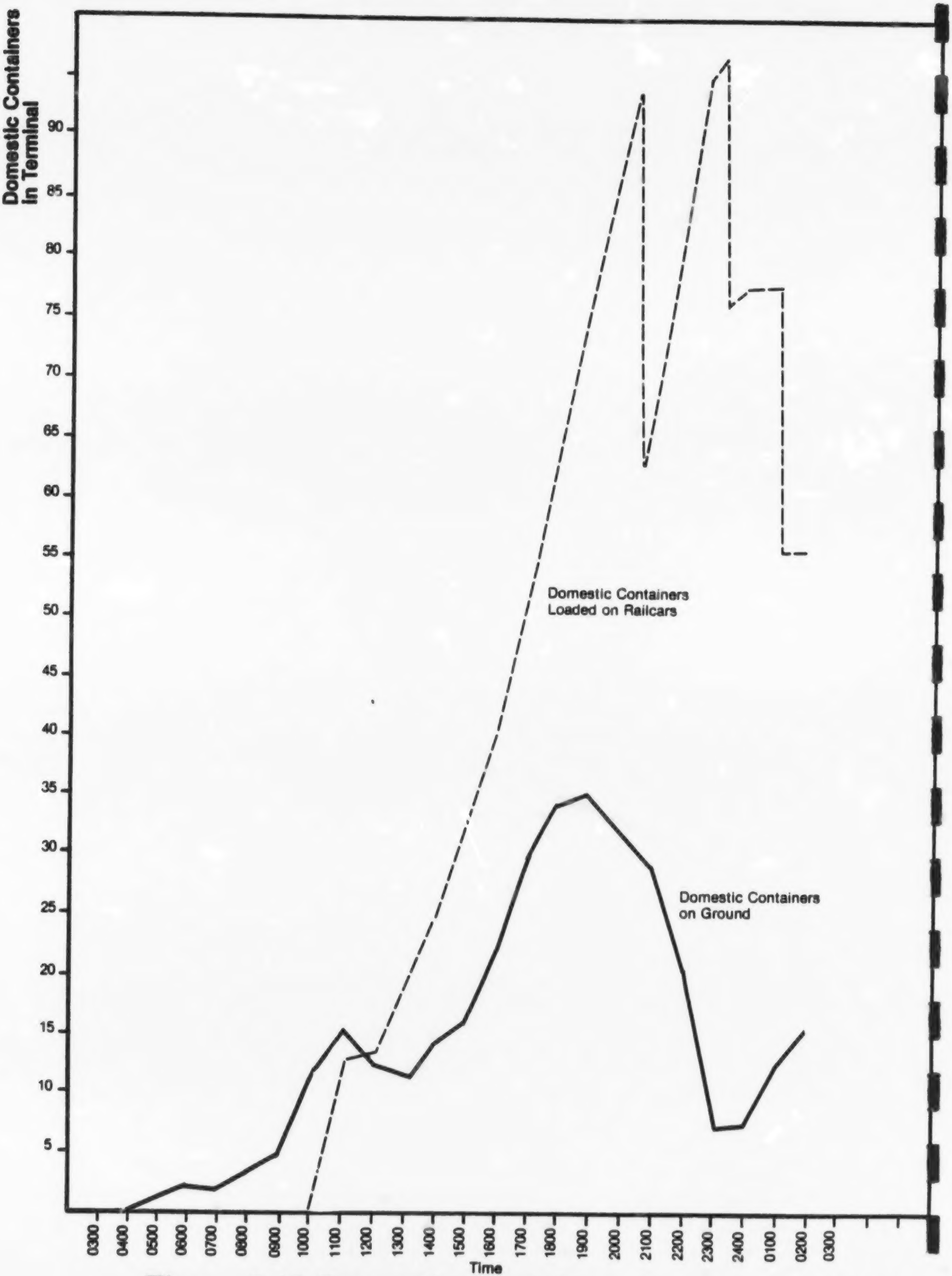


Figure 2.13 Domestic Containers Departing by Rail

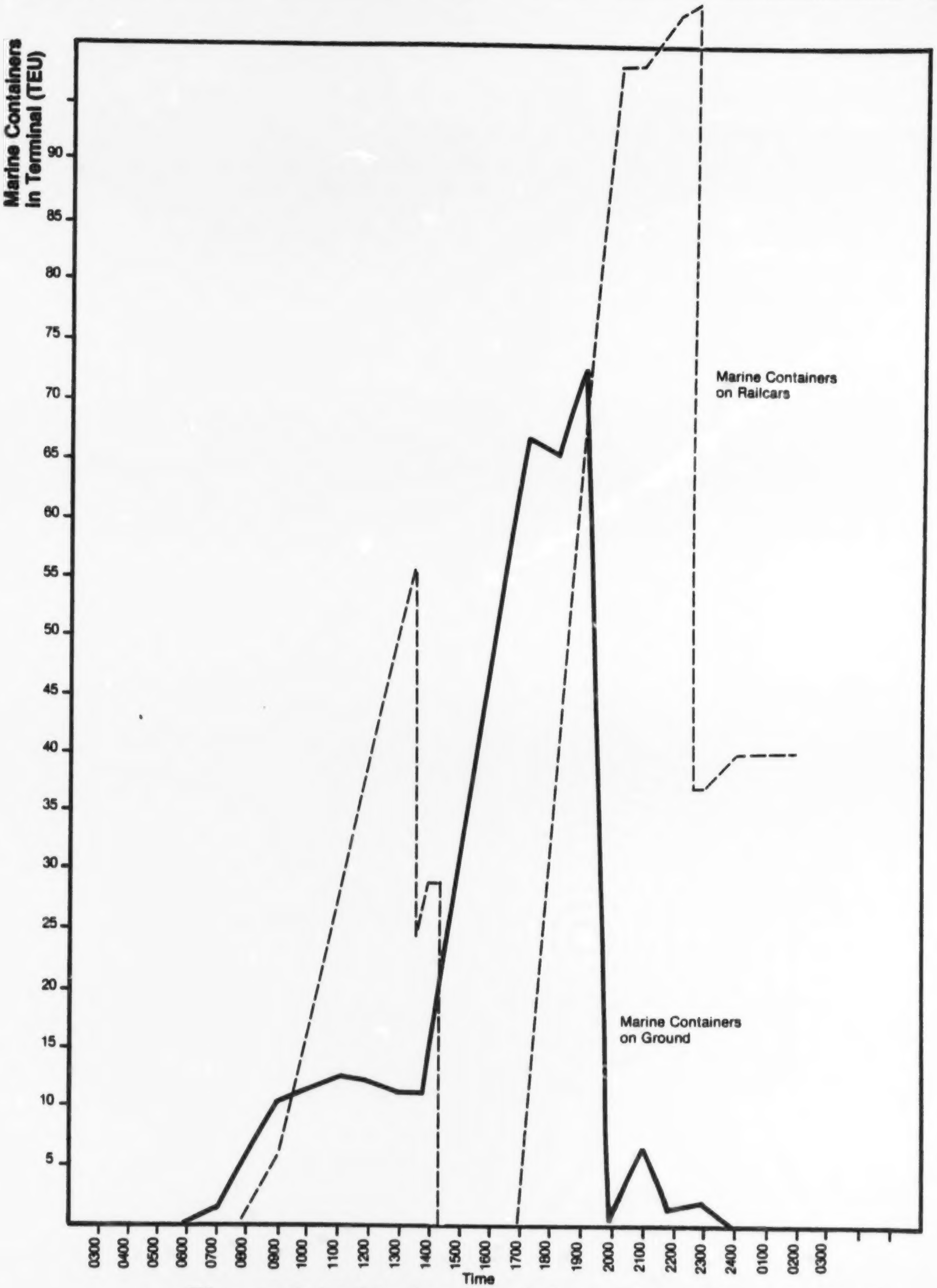


Figure 2.14 Marine Containers Departing by Rail

8.6.3 Yard and Road Engine Activities

The yard and road engine activities are shown in Figure 2.15. Two important conclusions may be made from this figure:

- When the road engines are yarding trains or preparing for departure, the yard engine cannot work because the lead tracks to the terminal are blocked. On two occasions (at 1620 hours and 0040 hours), the yard engine worked while the road power was working as well. The coordination of these activities by the yard-master is essential to maintaining a high throughput of cars at this facility.

- The yard engine worked steadily through all shifts.

The simulation indicated that one more train could have been made up from 0200 hours to 0400 hours, the expected time of arrival of the train from Western Canada. There were still two trains at the terminal, however, one west and one east, at the end of the simulation.

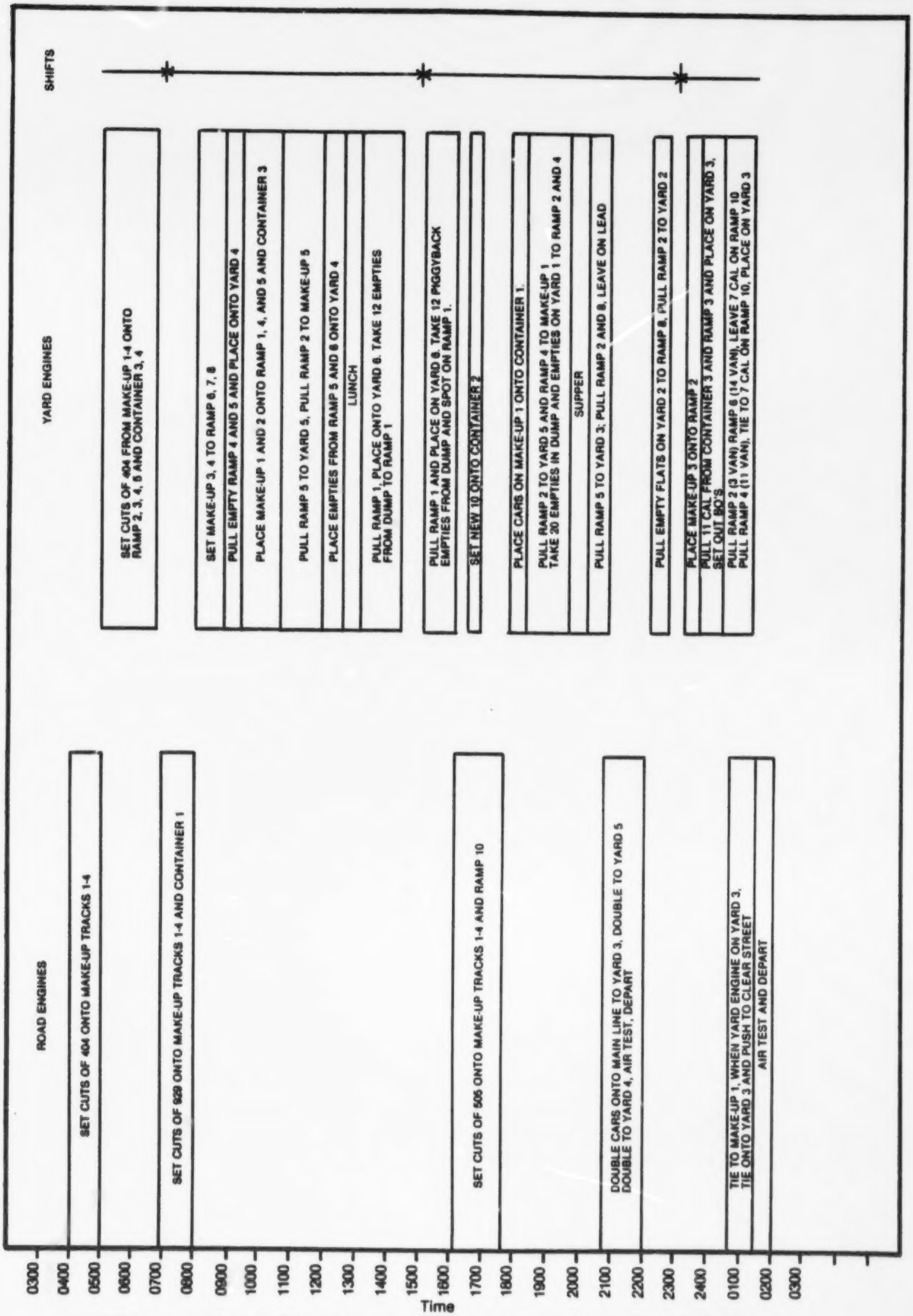


Figure 2.15 Yard and Road Engine Activities

8.6.4 Piggyback Ramp Activities

Piggyback ramp activities are shown in Figure 2.16. The time that arriving loads were placed and departing loads were pulled is also shown. In most instances, the unloading began as soon as the rail cars were placed. Trailers loaded each hour are indicated at the end of the hour and the total number of cars and trailers pulled is shown when the track was pulled.

The number of trailers ramped each hour is shown below:

Table 2.25 Number of Trailers Ramped

Hour Ending	Trailers Ramped
0600	18
0700	29
0800	10
0900	15
1000	26
1100	35
1200	9
1300	10
1400	5
1500	10
1600	10
1700	13
1800	21
1900	18
2000	12
2100	13
2200	8
2300	7
2400	8

As the maximum number of trailers ramped was 35 per hour, four ramp tractors worked steadily during this period. The last trailer arriving was ramped at 1100 hours.

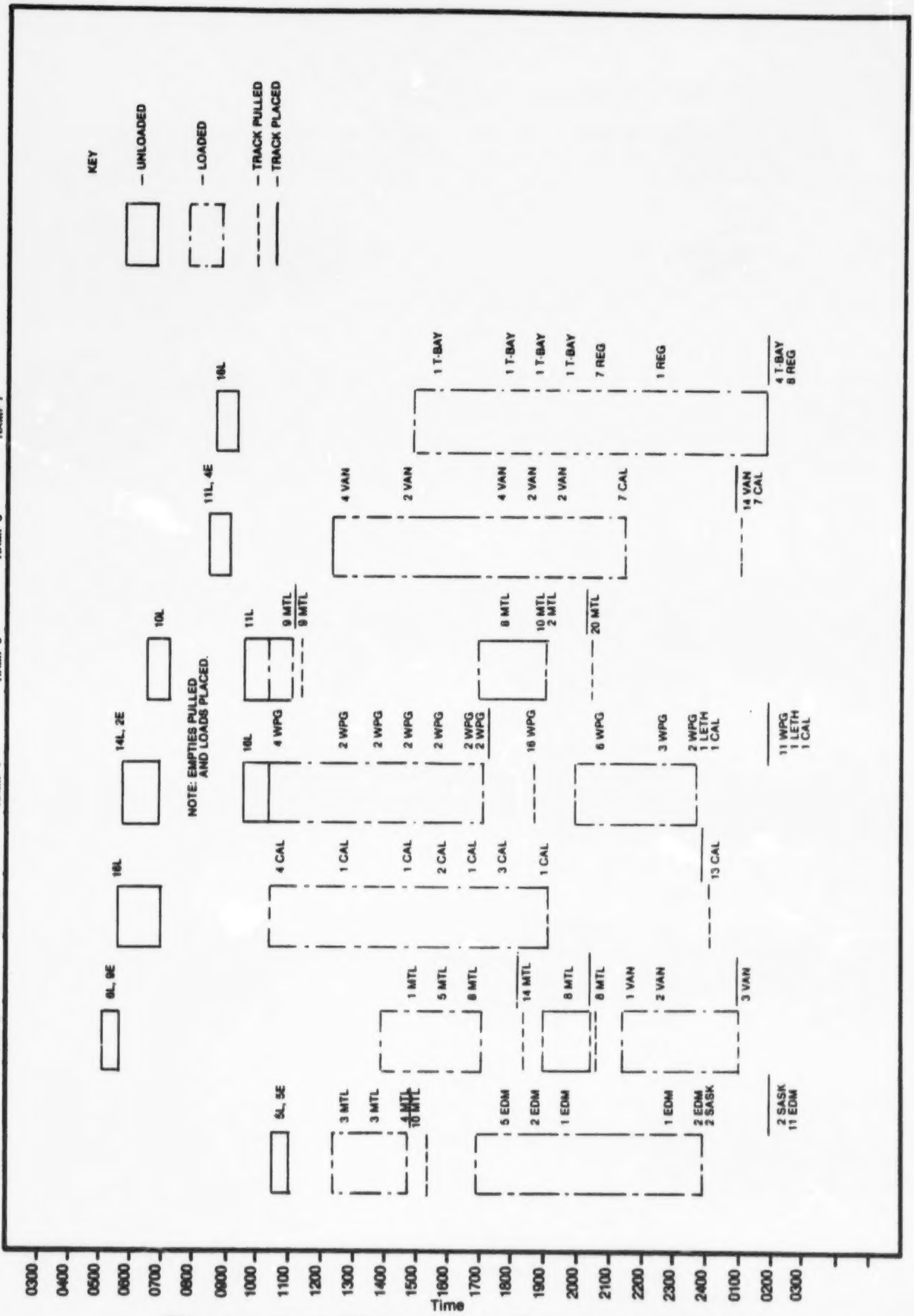


Figure 2.16 Piggyback Ramp Activities

8.6.5 Piggypacker Activities

It was assumed that two piggypackers would be available at the terminal, one to work between Ramp Tracks 8 and 9, and the other to work between Container Track 4 and Ramp Track 1. During the simulation, however, the Domestic Container cars were placed in Container Track 3 rather than Ramp Track 1. These placements were made because there was little marine container traffic prior to the arrival of the container train. Also, because 300 feet of Ramp Track 1 is parallel to the refrigerated container storage area, it was felt this track would be better suited to ramping trailers. The activities of the two piggypackers is shown in Figure 2.17.

The number of Domestic Containers handled each hour is shown below:

Table 2.26 Number of Domestic Containers Handled

	Domestic Containers		
Hour Ending	Loaded	Unloaded	Total
0700	0	18	18
0800	0	28	28
0900	0	27	27
1000	0	10	10
1100	13	7	20
1200	0	8	8
1300	7	0	7
1400	5	0	5
1500	8	0	8
1600	13	0	13
1700	10	0	10
1800	13	0	13
1900	12	0	13
2000	12	0	12
2100	10	0	10
2200	14	0	14
2300	17	0	17
2400	3	0	3

The other work done by the piggypackers included moving empties to the empty storage area and assisting with the unloading of the container train.

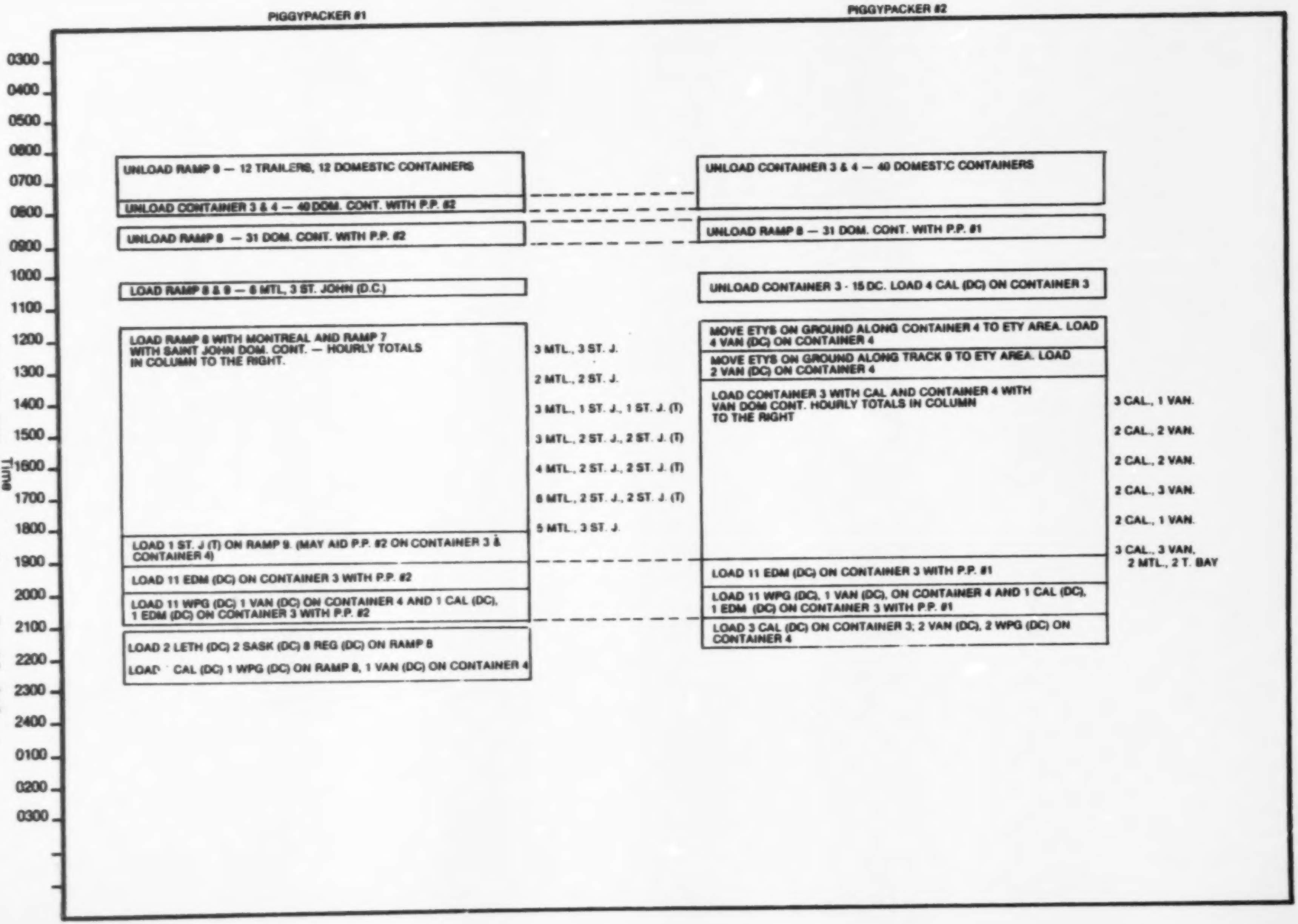


Figure 2.17 Piggypacker Activities

8.6.6 Toplifter Activities

The toplifter activities are shown in Figure 2.18. Given the late arrival of the container train and the small number of marine containers on the train from Eastern Canada, two toplifters were adequate until 1700 hours. From 1700 hours to 2000 hours, four toplifters were required and after 2000 hours, only one was necessary.

It should be noted that the piggypackers were able to assist in the handling of marine containers during parts of the day. At the end of the simulation, there were still 42 - 20-foot and 21 - 40-foot marine containers on the make-up tracks which formed part of the workload for the next day.

8.7 Conclusions from the Manual Simulation

In general, the simulation of the terminal indicates that the throughput capacity for arrivals by rail is adequate. A late arrival of 928 can be handled during the "slack" time in the early afternoon; however, although arrivals can be grounded, it will be at a reduced service level. For the day simulated, the last trailer was grounded at the ramps at 1100 hours and the last cut of cars was spotted for piggypacker handling at 1030 hours.

Problems developed in handling traffic to be forwarded by rail. Given the present cut-off times and track configurations, all traffic cannot be handled on a same-day basis. For trailer and Domestic Container traffic, the capacity of the yard is determined by the traffic forwarded, rather than by traffic received.

Storage was not a problem on the day studied. It is expected that Monday will be the critical day for storage and the storage requirements at 1984 levels have been shown in Tables 2.14 through 2.16.

A number of problems became apparent at the outset of the manual simulation. The problems and corrective actions taken were as follows:

- The model assumed that there would be no marine container cars in the terminal at 0300 Friday. This assumption would require the grounding of containers until the arrival of the container train. This arrangement is not practical and 15 cars (9 - 86-foot 7-inch, 4-slot and 6 - 49-foot 4-inch, 2-slot) were included for the loading of export traffic.
- The new tracks should be numbered 9 and 10 (i.e. Container 1 - 4, Ramp 1-8, 9, 10).
- Approximately 300 feet of Ramp Track 1 is required for refrigerated containers, reducing the capacity of this track for side loading. Domestic Containers were handled in Container 3 and 4 during the simulaton.

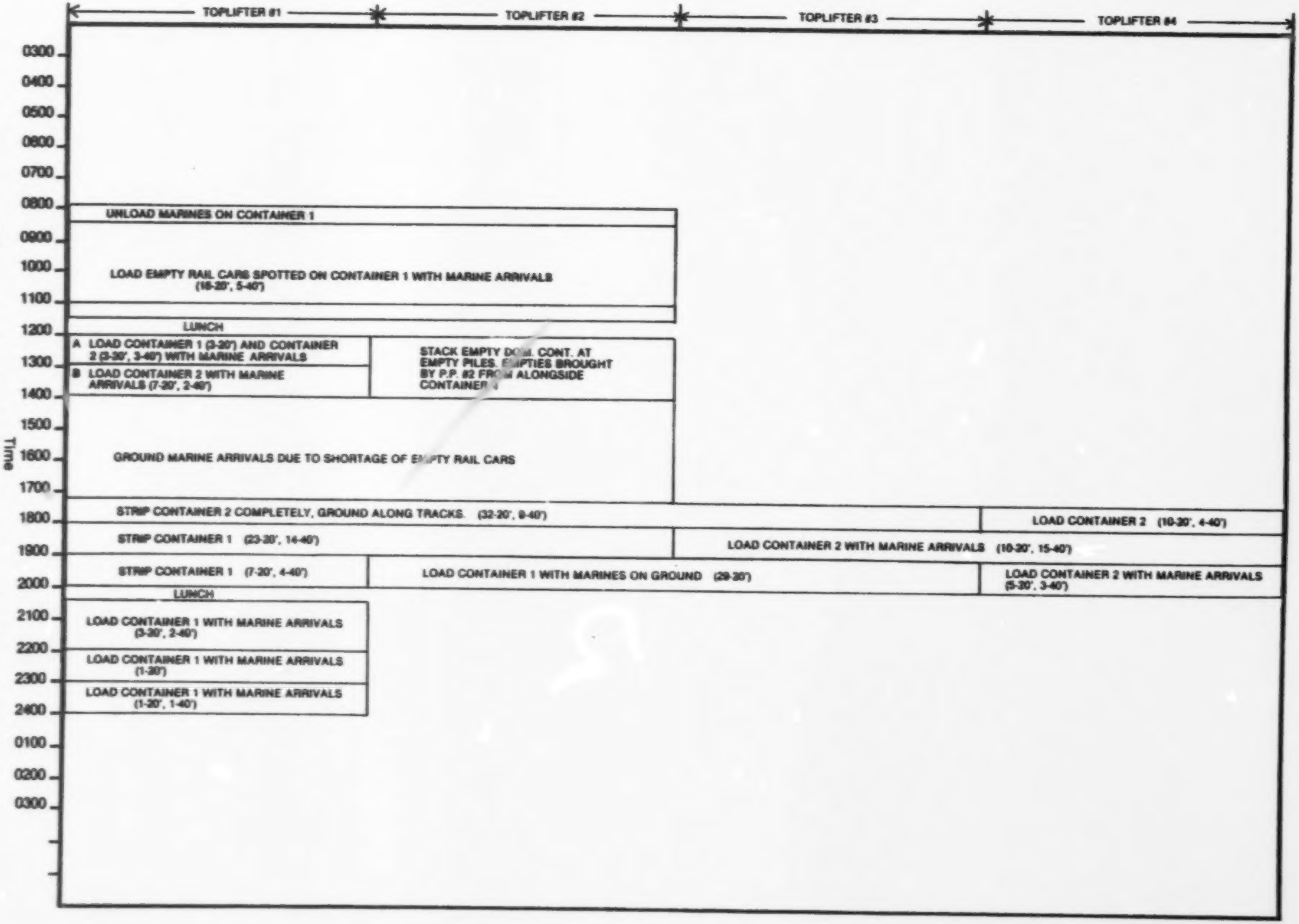


Figure 2.18 Toplifter Activities

- Provision must be made for storing Plan I-III trailers as these are not all released on the day of arrival.

- The lead track was blocked while the outbound intermodal trains were being assembled. Only one other train can be run prior to the yarding of the train from Western Canada for the next day. Possible solutions to this problem are:

  - Construct a road overpass over the main thoroughfare which would permit the construction of long departure tracks for outbound trains.

  - Construct a new lead to the container yard through the property on the north side of the present terminal.

  - Tie the south end of Track 8 into the make-up yard lead so that trains can be assembled from the south end.

- The number of destinations for Domestic Containers is too high. Domestic containers should not be loaded to points with low traffic volumes (e.g. Thunder Bay, Lethbridge).

- During the simulation, New Track 9 had Domestic Container flats mixed with trailer flat cars. This track should be loaded last as it provided flexibility for loading according to destination blocks and for accommodating late arrivals.

- The priority of trains from the terminal in 1984 should be:

  - a) the intermodal train to Eastern Canada;
  - b) the train for Western Canada with traffic for Vancouver and Calgary filled up with Winnipeg traffic;
  - c) remainder of Western Canada traffic;
  - d) remainder of Eastern Canada traffic.

- Empty trailer cars were required for loading between 1830 and 1900 hours. Loaded tracks must be released and replaced with empty cars prior to the marshalling of the Eastern Canada train.

- Empty cars must be readily available if the tracks are to be "turned over". Cars should be placed in the make-up yard rather than in the auxiliary storage yard (a 6-track, 3450-foot storage area located 700 feet north of the yard track area).

- A shortage of chassis is anticipated and it was suggested that the Domestic Containers be loaded off rail cars directly onto chassis from which a container had been loaded directly onto a rail car.

- The loading line is too short and as a result, some trailers for loading will be placed into the storage area prior to loading.

9. CAPACITY OF THE REVISED INTERMODAL TERMINAL

9.1 Handling Demand

The forecasts of annual handlings and of daily rail demand are shown in Tables 2.1 and Table 2.8 respectively.

Daily operational data for the various types of traffic are shown in:

- . Table 2.17 Trailers;
- . Table 2.18 Domestic Containers - Plan II;
- . Table 2.19 Marine Container Handlings.

The ability of the revised terminal to handle these traffic volumes is discussed below.

9.2 Marine Containers

9.2.1 Adequacy of the Revised Storage Capacity

Assuming that rail cars are unloaded 7 days a week, the maximum number of marine containers to be stored at the main terminal in 1984 is estimated to be 931 (652 - 20-foot; 279 - 40-foot; 1210 TEU) as shown in Table 2.20. The practical storage capacity of the revised terminal shown in Table 2.24 is 1366 TEU.

Providing that all of the empty marine containers are stored off-site, the practical storage capacity of the revised terminal is greater than the maximum number of loaded marine containers to be stored.

9.2.2 Adequacy of the Revised Track Capacity

The model assumed that approximately 60 percent of the marine containers received would arrive on two days of the week. The length of track required to yard all of the rail cars during these days is 6130 feet.

The length of track required on the peak day for marine containers forwarded, including Plan II marine containers, is 6467 feet.

The proposed track utilization scheme provides only three tracks with a total length of 4650 feet for handling marine containers.

The terminal will not have adequate track capacity for marine containers forwarded on two days of the week - Tuesday and Thursday.

9.2.3 Proposal to Revise Traffic Patterns

For traffic received, the shortage of track capacity could be avoided if the tracks were "turned-over" more than once a day. This level of productivity would require that one track be stripped and the empty rail cars switched out and replaced with loaded rail cars twice a week. Alternatively, traffic could be held out and handled the next day. The number of cars to be held out is as follows:

Table 2.27 Marine Containers Held Out of the Terminal on Account of Inadequate Trackage

Day	Containers Received	Track Length Required	Track Length Shortfall	Containers Held-Out To Next Day	Track Length Required On Next Day
Sunday	200	6130	1480	48	4650
Monday	56	1716			3196
Tuesday	56	1716			1716
Wednesday	56	1716			1716
Thursday	56	1716			1716
Friday	200	6130	1480	48	4650
Saturday	56	1760			3196

9.3 Trailer and Domestic Container Traffic

For traffic forwarded, the track length shortfall is 1817 feet on Tuesday and 775 feet on Thursday. Because cars are loaded on these days, they must be switched out and replaced with empty cars.

9.3.1 Adequacy of the Revised Storage Capacity

The parking area required for trailers and Domestic Containers on chassis, assuming that all loaded containers are stored on chassis, will be as follows:

Year	Trailers Loaded & Empty(1)	Loaded Domestic Containers(1)	Total	Revised Capacity	Shortfall
1981	379	43	422	243	179
1982	369	80	449	243	206
1983	344	124	468	243	225
1984	335	164	499	243	256

(1) Sunday Midnight

As the practical storage capacity of Lines 1 to 5 is 243 trailers or chassis as indicated in Table 4.24, it is recommended that immediate action be taken to acquire an off-site parking area for trailers or containers on chassis, or for the empty Domestic Containers (see Section 7.7).

9.3.2 Adequacy of the Revised Track Capacity

Table 2.8 shows that the maximum number of trailers forwarded in one day in 1984 will be 194, and that slightly fewer will be forwarded on other weekdays. As trailers are received over seven days of the week, the number received is not critical.

Table 2.8 also shows that the maximum number of domestic containers forwarded on one day in 1984 will be 147 and that slightly fewer will be forwarded on other weekdays. As Domestic Containers are received over seven days of the week, the number received is not critical.

The track length required for trailers and Domestic Containers is developed in Table 2.20 and is compared to track length available as shown in Table 2.28.

Table 2.28 Track Utilization for Trailers & Domestic Containers

Year	Track Length Required		Turning All Tracks Once Per Day			Turn Ramp 5, 6; Container 4 Twice		
	Type of Traffic	Track Length (feet)	Track Used	Track Length (feet)	Shortfall (feet)	Track Used	Track Length (feet)	Shortfall (feet)
1981	Trailers	12,668	Ramp 1-7 Ramp 8 New 9	7,370 1,400 1,350		Ramp 1-7 Ramp 8 New 9	9,770 1,400 1,350	
				10,120	2,548		12,520	(148)
	Domestic Containers	1,894	Container 4	1,650	244	Container 4	3,300	(1,406)
1982	Trailers	12,265	Ramp 1-7 Container 4	7,370 1,650		Ramp 1-7 Container 4	9,770 3,300	
				9,020	3,245		13,070	845
	Domestic Containers	3,408	Ramp 8 New 9	1,400 1,350		Ramp 8 New 9	1,400 1,350	
				2,750	658		2,750	658
1983	Trailers	11,459	Ramp 1-7	7,370	4,125	Ramp 1-7	7,370	4,125
	Domestic Containers	5,301	Ramp 8 New 9 Container 4	1,400 1,350 1,650		Ramp 8 New 9 Container 4	1,400 1,350 1,650	
				4,400	901		4,400	901
1984	Trailers	11,171	Ramp 2-7	6,500	4,671	Ramp 2-7	6,500	4,671
	Domestic Containers	7,005	Container 4 Ramp 1 & 8 New 9	1,650 2,270 1,350		Container 4 Ramp 1 & 8 New 9	1,650 2,270 1,350	
				5,270	1,735		5,270	1,735

Ideally rail cars should be spotted for unloading, be unloaded and re-loaded prior to pulling. As the terminal receives traffic in the morning and forwards traffic late in the evening, it is desirable to have the tracks turned once daily.

Allowing for the turning two of the ramp tracks, say Ramp 5 and 6, twice daily would add the equivalent of 2400 feet of ramp track capacity. Turning Container Track 4 would add the equivalent of 1650 feet of track capacity for containers and trailers. Assuming that the turning of these tracks can be accomplished, the track capacity for both trailers and Domestic Containers will be exceeded in 1983 and other arrangements must be made.

9.3.3 Relationship of Domestic Containers to Trailers

Piggypackers will be used to handle Domestic Containers and trailers spotted in tracks Container 4, Ramp 1 and 8, and New 9. In an ideal terminal, the tracks should be spaced such that all trailers and container traffic can be side-loaded.

Further studies involving the use of piggyback layouts and gantry cranes should be made in order to evaluate the trade-offs of higher capital investment versus savings in land area and trackage requirements. These studies will be required in order to evaluate the cost of moving to a larger expanded site or remaining at the improved present location. These options are discussed in more detail in Appendix III.

Annex I Summary of "Intermodal Freight Terminal Simulation - Requirements Definition"

I.1 Introduction

This Federal Railways Administrtion (FRA) report presents the results of a study of the potential applicability of an intermodal freight terminal simulator (IFTS). It also provides a definition of the requirements for such a simulation of an intermodal truck/rail terminal including a computer, a visual display of terminal status and a human operator to make terminal operating decisions. The computer would generate traffic and anomalies, as well as record the results and calculate the statistics, while the human operator would make decisions in much the same way he would in a full-scale terminal.

I.2 Users of an Intermodal Freight Terminal Simulator (IFTS)

Groups within a railroad organization, each of which may have different objectives, should benefit from the implementation of an IFTS. The following section details these different groups and how and IFTS could be useful to them.

1.2.1 Terminal Operators

Terminal operators are involved in the day-to-day running of a terminal. Their objectives are basically short-term and involve non-capital and procedural decisions such as labour management and operating strategies. The major categories of procedures include:

- equipment allocation and circulation;
- load/unload sequences;
- parking organization;
- the handling of different units (reefer, heated, etc.).

A simulator model would help to evaluate the impact of different operating procedures within a pre-determined terminal layout and equipment complement.

If the simulator is well designed and realistic enough, it can be used by the terminal operators to train new operators or dispatchers and allow them to simulate "hands-on" experience in order to find out the operating procedures for the terminal and to determine their role within the system. The simulator could also be used to familiarize an experienced operator who is being transferred to a new facility.

Terminal operators would also provide the operator who makes the decisions during the simulator runs.

I.2.2 Planners

Planners are defined as the group which generally conceives and evaluates terminal designs and major operational changes. The planners study overall terminal performance and evaluate alternative plans in terms of throughput capacity, cost, efficiency, customer service and interaction with other parts of the rail or truck systems.

The Intermodal Freight Terminal Simulator would provide a useful planning tool for evaluating the various influences which affect terminal performance. Although they cannot make decisions concerning capital expenditures or allocation, they are the people who must recommend to management, for approval. The major influences determined are:

- physical layout;
- line-haul and terminal handling equipment;
- operating strategies;
- information management systems;
- anomalies.

The simulator would allow the fast, inexpensive evaluation of "what-if" scenarios involving one or more of the above factors and their impact on such performance measures as throughput capacity, dwell time of trailers, operating efficiency and operating cost.

The planners in their role of "recommenders" could use the simulation runs as an audio-visual tool with which to present their case to management for approval.

In the long-run, an extensive use could supply the data needed to help formulate a set of guidelines for terminal planning.

I.2.3 Management

Management decides which terminal improvement plans are to be approved for implementation and which are to be rejected. Although management would not use the simulator directly, it would be used as a communication tool by both the operators and planners to argue the need for changes and illustrate the factors which might influence their decisions.

I.3 General Characteristics of Simulation Models

A review of the literature concerning simulation techniques highlights different characteristics depending on application.

I.3.1 Interactive versus Man-Machine versus Man-in-the-loop

The terms "interactive", "man-machine" and "man-in-the-loop" were researched in order to determine which one would best describe the "decision-maker within the simulation run" characteristic. "Inter-active" is used for any system run through a computer terminal as opposed to a "batch" system. The "man-machine" concept concerns the simulation of human behaviour rather than human influence within the process. The term "man-in-the-loop" best describes the involvement of the user in making operational decisions during the simulation.

"Man-in-the-Loop" simulations allow the evaluation of detailed terminal design decisions, but would probably benefit from faster mathematical methods for the screening of the options to be studied.

I.3.2 Continuous versus Discrete Events

Continuous simulation describes events which are best handled through functional relationships and differential equations. Discrete event simulation is used when a process is best described by a series of well defined events.

I.3.3 Aggregate versus Microscopic

Aggregate simulation will show flows in numbers only and is really not suitable for the study of discrete events. What would be needed for the intermodal freight terminal simulator is a microscopic model which would simulate the traffic flow of individual vehicles or trailers and containers within the terminal area.

I.3.4 Network versus Two-Dimensional Orientation

This section seeks to define the environment in which the simulation must run. A network is defined as a set of points connected by paths. The movement is only possible along the paths from node to node. The intermodal freight terminal simulation would require a two-dimensional environment so that movement is not restricted to specified points, thus allowing, for example, the operator to park a trailer anywhere within the terminal area.

I.4 Requirements For An Intermodal Freight Terminal Simulator

The FRA study determines eight requirements that the intermodal freight terminal simulator must meet. They are:

- "man-in-the-loop";
- discrete event simulation;
- microscopic;
- fully two-dimensional;
- accurate replication;
- flexibility;
- convenience;
- reasonable operating cost.

The first four requirements were outlined in the previous section. This section will concentrate on the definition of the last four requirements.

I.4.1 Accurate Replication

A simulation model seeks to replicate a real work situation and the more accurate the replication, the more valuable the model will be. The few major aspects of a terminal operation that should be replicated are:

- physical activity within the terminal;
- decisions made regarding terminal activity.

I.4.2 Flexibility

One of the major uses for the simulator model is to help analyze a variety of terminal design and operating strategies. The model should be flexible enough to easily modify any variable that influences terminal performance and would include physical layout, operating strategies, and levels and types of traffic.

I.4.3 Convenience

Convenience is defined as ease-of-use. The model should be designed to allow the efficient use of the operator's time and incorporate features which make multiple runs easier. These features would be:

- clear and simple methods of communication;
- instant access to equipment status information;
- clear and complete output for feed-back and analysis;
- reproducibility of input for subsequent runs;
- retracing ability to resume a simulation at any past point required.

I.4.4 Reasonable Utilization Cost

Whether or not to use the intermodal freight terminal simulator will be determined in part by its implementation and operating cost. If the system is to be used extensively, it should be based on a portable mini-computer or linked to a time-sharing service.

The input needed to initialize the system should be readily available with a minimum of further processing, and finally, thought should be given to the trade-off between the cost and need of incorporating expensive features such as the level of detail in replication and the level of "user friendliness".

Although not covered in this summary, the FRA report covers the development plan suggested to implement such a computer-assisted simulator and examines in detail the trade-offs between the features considered.

Annex II Visit to the Railway Technical, Derby, England

II.1 Objectives

The container handling simulator is a computer system created for use in a project undertaken by the Railway Technical Centre (RTC) for Freightliners Ltd. Freightliners is a part of British Rail which operates container terminals in many industrial centres throughout Great Britain. Its concern was that the overhead cranes used for container movement on and off trains, were getting old. In order to delay the considerable expense of replacing these cranes, the company was interested in extending their working life as much as possible. An important aspect of this system is crane movement.

The project's principal objective was to study various strategies of crane movement with a view to optimizing such factors as long travel, lift ratio and idle time.

The Freightliner terminal chosen for study was at Trafford Park, Manchester.

The overall direction of the project was provided by a committee of Freightliners and RTC personnel.

II.2 Project Structure

The project was regarded as a four-phase feasibility study, whose output was the development of recommendations for optimizing crane usage and improving operational efficiency in other areas. The project was at the Phase IV stage at the time of the visit. A brief description of each phase follows:

II.2.1 Phase 1: Initial Survey

. Familiarization with the current operations at Trafford Park and collection of operational and statistical data, e.g. log of crane/container/truck/train movements;
  - determine cycle times for various movements;
  - obtain data on crane reliability.

This work was done by Freightliner personnel during visits to Trafford Park.

. Report on the initial findings;
  - agree on the major parameters involved in terminal operations;
  - agree on the "shape" of the model to be used in the study;
  - identify areas of operation where methods could be improved, for example:
    - better control of container placement;
    - different layouts of storage areas;
    - maintenance schedules.

II.2.2 Phase 2: Develop the Simulation Model To Study Various Operating Stages

- Determine the model structure and scope, the algorithms to be used for crane/train/truck moves; the visual displays and reporting and the statistics to be tracked.
- Demonstrate the model and validate the results.
- Review how the model is to be used in Phase 3 via meetings with the terminal operating personnel.

II.2.3 Phase 3: Model Use

- Simulate the chosen operating strategies.
- Analyse and report the results to the project committee.
- Recommend an operations and methods study to look at existing control office procedures.

II.2.4 Phase 4: Operations and Methods Study

This study should lead to improved operating methods and the tighter control of movements within the terminal, possibly with the assistance of a computer system.

II.3 Simulator Facilities

The model is constructed specifically to study operations involving the Arrol cranes at Trafford Park Terminal. In particular, the objective is to determine which operating strategies will optimize crane movements from the viewpoint of long travel, lift ratio and idle time.

Crane movements statistics (e.g. cycle times and breakdown data) were gathered from records in the terminal control office.

Procedures and logic rules were deduced from observations made in the yard area of the terminal during Phase 1 (initial study) of the project. This was an 'intellectual' process based on the data gathered from observed yard activity, not a mathematical or theoretical approach.

Statistical routines are used to cause truck movements (collection and delivery) and crane breakdowns.

The following areas of terminal activity are catered for:

. crane movement	- empty - loaded
. container transfer	- train to train - truck to train - train to truck
. train movement	- arrive - depart - shunt

Note that the emphasis is on crane movements; the model lacks detail in the areas of:

- truck movements - trucks appear and disappear on the screen plays and very simple statistics are kept. The processing of trucks at the terminal gate is not handled.

- internal container movements - they are only recognized if they are handled by a crane.

- container movements by machines other than the cranes - movements by straddle carriers and front-loaders are not recognized.

The simulator system operates on a Sperry-Univac computer installed in the Railway Technical Centre. The system has taken 6 men-months to develop to its current status and was written by one programmer with an assistant. Very little documentation exists for the system. What does exist is mostly in note form. The main documentation is the listings of the computer modules.

II.3.1 Replay of Actual Terminal Activity

The replay uses a log of crane, train and truck movements observed over a given time period in the yard (e.g. a shift) as input to the simulation. This procedure is useful in several ways:

- It can be used to calibrate the simulator, i.e. to test that the simulator system produces the same results as the original movements. This calibration is vital in establishing the validity of the simulator.
- The simulation produces statistics from actual activities which can be used for further analysis.
- Observation of the screen display as it changes during the simulation may reveal features of the activity which were not evident during the original observations in the yard, or from the resulting activity log.

II.3.2 Optimization of Crane Movement

Using the actual situation in the yard as a starting point, and the actual pattern of train and truck movements observed in a given time period, the simulator generates crane movements. Priorities for this optimization are:

- a) get containers off a train about to leave;
- b) get containers onto a train about to leave:
- c) handle the truck queue in order to minimize waiting;
- d) make all other movements with a minimum of crane travel and a minimum of empty moves.

An optimization run from the same starting point as a replay run will provide useful comparisons between the efficiency of the terminal using current procedures, and the efficiency resulting from applying the above priorities to crane movements. These priorities were pre-determined in consultation with Freightliners operating staff.

II.3.3 Interactive Simulation of Crane Movements

This mode uses the same information as the optimization mode; however, the crane movements are determined by 'crane operators' (one for each crane) using any criteria they wish.

Several simulations using different operating philosophies can be run from the same starting point which allows a comparison to be made between the current priorities (optimization mode), and the experimental operating methods tried in the interactive mode.

II.3.4 Progress of Simulation

In all modes, the movements of cranes, trucks, trailers and trains take place in discrete steps of 20 seconds of simulator time, and each screen is refreshed at each time interval.

In the replay mode, the input event tape controls the movements, and the simulator proceeds at approximately three times real speed if the displays are used. If the simulator is run in this mode without the displays (i.e. for statistics only), the simulation runs at one hundred times real speed.

In the optimization mode, less reading of the paper tape input is done, and the simulation proceeds at approximately ten times real speed.

In the interactive mode, the speed of simulation depends on the human operations.

By using control commands, the simulation can be started, stopped, advanced, restarted at a prior point, repeated, etc.

Printed reports can also be generated on request during the simulation operations.

II.4 Thechnical Details of the Simulator System

II.4.1 Computer Configuration

The computer is a twin Sperry-Univac V76 computer installed at the Railway Technical Centre and used by the Mathematics Application Group. Its characteristics are as follows:

. Memory: M/C 1 - 128 K words (16 bits)
M/C 2 - 32 K words
Sharable - 16 K words

. Storage: disks - 2 units per M/C - 1 fixed
1 sharable

. I/O: Console - 1 teletype per machine
Paper Tape - 1 reader/punch
Card - 1 reader
Video - 2 Hazeline units with screen and keyboard

II.4.2 Structure and Operating Modes

The simulator routines are written in Fortran. There is one routine for each move in the repertoire plus various control functions to permit the following 3 modes of operation:

. Replay - driven by a pre-coded series of events involving cranes/trains/trucks.

. Optimization - The simulator makes the movements given the starting disposition of containers and train movements.

This routine uses two additional modules:

NEXTCON - determines the next container to move;

WHERE - decides where it will go.

. Interactive - Using the same information as the optimization mode, an operator can make the moves (i.e. do the same functions as NEXTCON and WHERE).

II.4.3 Reporting

A simple summary of event by time is produced on request.

In the optimization and interactive modes, a log of all movements made in the simulation is produced which can be used for further analysis.

Each video display unit show half of the crane area. One shows the current status and activity of Crane 1 together with the cumulative statistics on crane movement. The other screen displays the same information for Crane 2.

II.4.4 Data Content

The layout of the terminal train tracks and container storage is kept as an array. Before a simulation begins, this array is filled with the initial positions of trains, containers and tracks from a paper tape. The initial positions of the cranes are also entered at this time.

During simulation, the contents of each position are continuously updated.

Details of train identity, destination and container complement (arriving with the train or to be loaded onto the train), references to the tracks occupied, and the position of each container on the train are kept. As container movements take place, the complement of containers is updated.

II.4.5 Operator Interfaces

During a simulation run, the operator communicates with the system via the Hazeline VDU's which are used as consoles for the entry of commands to control the time positioning and advance of the simulation. As each move is made, it is shown on the screen.

In the interactive mode of operation, an operator enters movement instructions. This procedure needs one unit to format the instructions and to validate them. If the simulation involves both cranes, the teletype unit can be used to enter the moves. If only one crane is being used, the other VDU can be the console which allows faster communication, and hence faster simulation progress.

II.5 Current Status of the Simulator

The simulator has provided useful insights into the operations at Trafford Park, and possible operating strategies which could be used to improve crane use.

Currently the simulator is dormant, Phase 3 of the study having been completed. There are no plans to develop the system's facilities further.

The simulator could be used to study other Freightliners terminals if its terminal-specific components were altered to suit.

The pictorial method of displaying the terminal layout on visual display units is convenient since it removes the necessity for a separate layout board. Also, the position changes of cranes, containers, trucks and trains can be shown automatically as they occur. The size and shape of area that can be dealt with in a simulation are, however, limited by the data capacity of the visual display units used in the Sperry-Univac system. Other models of display units may overcome this limitation.

II.5.1. Computer System in Container Operations

Freightliners Ltd. is developing a computer system to control its container operations called COPS (Computer Operations Processing System). It will be derived from a System originating at Southern Pacific (called TOPS).

COPS will be similar to TOPS, but customized for Freightliners. It will use a central computer plus terminals at each Freightliner depot. COPS will track each container in the freightliner System as it moves.

There is currently no effort being made to implement computer systems to control the internal operations of container terminals at Freightliners.

Annex III Visit To The Mersey Docks & Harbour Co. Liverpool, England

III.1 Objectives of the Visit

The objective of the visit was to:

- get more detailed information on the container terminal simulator package developed my MDHC;
- dicuss the container in[illegible]ion control system (CONICS) in use at the Royal Seaf[illegible] Container Terminal, Liverpool.

III.1.1 Results of the Visit

The initial impression of the simulator is that it appears to be extremely flexible and comprehensive in that all aspects of container terminal layout, machinery and operating methods can be simulated. During discussions with MDHC personnel, however, it became apparent that a significant amount of expertise is necessary to do a meaningful simulation and to evaluate it.

The current package does not handle rail operations, but MDHC personnel felt that this could be accommodated by treating a train as a stack of containers in the initial simulations, and by writing more modules (similar to these used for ship handling) for use in the longer term.

Documentation on the system's specification or capabilities was not obtainable during this initial visit. From this visit, it appears that it may be profitable to do a definitive assessment of the simulator's suitability for intermodal purposes.

III.2. Container Terminal Simulation System

III.2.1 Model Scope and Content

The simulation system is intended to model all aspects of the operation of a container terminal as follows:

. Shipside Operation	- One or more ships with known hold contents can be simulated. - The position of the ship at the quay is specified. - The arrival and departure times are specified. - The movement of containers can be handled by any kind of crane.
. Landside Operation	- The movement of containers can be done by any type of handling machinery. - The complement of handling machines can be specified for the simulation. - All significant operating characteristics (working cycle times, reliability etc.) can be input.
. Terminal Geometry	- Any configuration of stacks and grids can be handled.
. Distribution of Containers	- The system tracks the location of all containers relevent to the simulation: - In the park for import; - to be delivered for export; - in the holds of ships; - to be loaded into ships.
. Repertoire of Moves	- The user specifies each different 'micro' move as a string of 'micro' movements. This procedure allows each cycle speed, distance travelled, etc., in each individual movement component to be more accurately allowed for.

III.2.2 Simulation Session

The personnel required for a simulation session are:

- a shipside operator who handles the moves within the ship container park;
- a landside operator who handles the movements between the trucks and the container park;
- an administrator who guides the overall progress of the session and who keeps watch on the usage of the handling machinery and the efficiency indicators (such as the throughput report). He may also act as a supervisor to the other operators.

The administrator usually controls the clock advance which is manually restarted after each activity entry session.

III.2.3 Session Activities

Each operator determines which container moves to make by working from the following current status and operating documents:

- shipside - the ship arrival and departure schedule(s);
  - the containers to be loaded or unloaded in each hold;
- landside - the queue of trucks with which to pick up or deliver containers.

III.2.3.1 Session Activity Cycle

Initially, the clock is stopped. Both operators plan as many moves as possible and enter them via the visual display units. When both operators have entered all the moves they can think of at that time, the administrator starts the clock.

The clock runs as long as all the machinery currently in use is operating. The first machine to become free or break down stops the clock.

The operator then enter more moves, and the administrator starts the clock again.

III.2.3.2 Random Activity

During these cycles, the arrival of trucks is controlled by the statistics of truck movements fed in during initial loading of information. Similarly, machinery breaks down at random times for random lengths of time as determined by the reliability statistics.

III.2.3.3 Update of Information

As each container is moved, the system keeps track of its location. This information can be displayed upon request. The operator also manually moves the containers on the display board so that the two correspond at all times.

III.2.3.4 Monitoring of Simulation Progress

By using the various displays available in the system, the administrator can monitor the progress of the simulation from such aspects as machine usage, cumulative activity counts, status of ship holds and location of containers in the park.

III.2.3.4 Analysis and Reporting

Using the information collected during the simulation session, plus comments from the operators and his own impressions, the administrator writes the final report on the simulator.

III.3 Evaluation of the MDHC Simulation Package

In discussions with MDHC personnel, it was agreed that a cautious approach to the use of the simulator would be appropriate in order to avoid the pitfalls involved in applying a generalized package to a specific application.

III.3.1 Suitability of Package

Any user must be sure that the package is capable of meeting its application requirements. These requirements would include:

- Application specifications: These specifications could follow from the data collection and the investigation of the container terminal operations currently being done as part of this study project. The experience gained in constructing the planned manual model would also be valuable here.
- MDHC application specifications: The package is extremely flexible with practically every parameter being adjustable; however, there are limits and assumptions within the system which may not be evident unless specifically investigated.

A 'definition of capabilities' document would address these points; also, detailed documentation on simulations already done would provide some insight into their size and scope. MDHC does not have this type of documentation, but agrees that it would be appropriate. These documents may be provided in the future.

III.3.2 Initial Trials

MDHC should run a demonstration simulation for potential users. This demonstration should be designed and set up by the user, using layouts and other familiar data. The simulation would be run in Liverpool.

The data for this demonstration would be coded on input forms supplied by MDHC. The user requires full instructions for filling out the forms because they need upgrading for use by inexperienced people.

III.3.3 Evaluation of the Package

Based upon the information presented in Sections III.3.2 and III.3.2, the user can evaluate the suitability of the package. As part of this process, the application specifications should be finalized and sent to MDHC for their evaluation.

One finding of this evaluation would be an assessment of the changes necessary to accommodate rail operations, and any difference in the operating characteristics between a ship terminal and a rail terminal.

III.3.4 Transfer the Simulator to Another Location

Visits by several user personnel to Liverpool for training, and possibly a visit by an MDHC person to the test site, would be required in order to ensure the successful installation of the package in its new environment. The final step would be a repeat of the demonstration simulation originally done in Liverpool.

III.4 Obtaining the Use of the Simulator

Various combinations of purchase and lease are available and could involve the operation by the user or by MDHC. Either option must consider the availability of MDHC personnel for consultation and for the training of user personnel.

The basic assumption is that the railways will want to use the simulator over a long period of time (several years) for their own studies. Additionally, other organizations may be interested (e.g. TDC and FRA). The best course of action in the long-term would be for the railways to purchase the system and generate the expertise to run the simulations in-house.

The use of the package on a consultancy basis would, however, be very useful in the short-term. During the discussions, it became evident that transferring the package to Canada will involve considerable effort.

Before any commitments are made, the user must be certain that the package contains all of the necessary facilities. This assurance can only be obtained by running at least one demonstration simulation using data created by the user.

While the current package covers both landside and shipside operations, the landside operations only cover truck transport. MDHC does not feel that handling rail operations is difficult and could in fact be accomodated in the current system. For long-term use, however, this feature should be included in a proper and complete manner. It would involve testing runs to verify the new facilities from the user's point of view. In addition, changes to the system will be necessary if the new computer environment or configuration is not identical to the current MDHC setup. MDHC programmers would be the best qualified to make the changes outlined above.

MDHC are willing to provide all assistance necessary for the user to transfer the simulator to his location, to run simulations, and to support the system software. This work would be charged at appropriate commercial consultancy rates.

III.5 Installation of the Package

III.5.1 Computer Environment

Since Canadian railways do not operate any IBM DOS System, the package will presumably be installed at a computer utility. If this utility operates a DOS System, the MDHC package could be changed to operate in this environment. This operation would likely involve changes to the job stream JCL statements and the adjustment of device access and randomizing routines if the I/O equipment is different. This installation is probably the best and most economical method for long-term use.

The package could be installed with much less change by using the same tactics as for the CONICS demonstrations, i.e.:

- find an IBM OS/VS environment;
- define a DOS/VS environment identical to the one at MDHC in Liverpool;
- install the MDHC environment in this virtual machine:
  - MDHC supervisor and system files;
  - simulator package.

Using this approach, changes would be confined to device access routines and file address randomizing routines should IBM 3340 disk units not be available. This approach would allow much faster installation in Canada and might be the best one to get things going quickly.

Presumably this way of operating the system will be more expensive, and eventually the system would be adjusted to operate in a real DOS or OS environment.

III.5.2 Simulation Site

At the location where the simulations are to be carried out, the following facilities will be required on a long-term basis:

- a room to accomodate:
  - 1 magnetic board of the terminal layout;
  - 3 visual display units - 3270 BR Compatible;
  - 1 printer - 3284 BR Compatible;
- communications lines and datasets to link the VDU's, the printer, and the host computer.

III.6 Container Information Simulation System (CONICS)

III.6.1 Results of Visit of the Royal Seaforth Container Terminal

The tour covered the container park area, the groupage sheds, and the berth office operation which included:

- the signing in and out of trucks and containers, including the entry of the booking advice for each container;
- the dispatching of trucks to the transfer areas;
- the controlling of the container handling operations by radio contact with the straddle carrier drivers;
- the various control and operations oriented displays.

CONICS is a very comprehensive system which tracks the movement of import and export containers and the associated paperwork while they are in the terminal. This system includes the routing of containers via customs as necessary.

One aspect of the shipside handling not included is the control of the placing containers in the ship's holds for correct sequencing by destination. This activity is done by shipping company personnel.

Included is the billing of demurrage charges to shipping companies who leave their containers in the park beyond a specified length of time (4 days or so).

In the near future, MDHC plans to extend the CONICS display facilities into shippers' offices in order to give them direct access to information about the containers which they are handling. This practice will reduce the current load of inquiries handled by MDHC personnel in the berth offices.

III.6.2 Technical Discussions

MDHC provided the following details of the service:

- CONICS is available for purchase at a current price of 30,000 pounds sterling. This price includes full documentation and all system modules.
- The system runs on an IBM DOS/VS/CICS environment, on the same computer as the simulator.
- The help of MDHC personnel is available at appropriate rates to install the system and to train operators in the computer terminal areas.

- To customize the Liverpool system for use at another terminal, changes in the following areas are necessary.
  - The physical layout of the container ports includes changing the content of the container park file, and the file definitions in all modules which access this file.
  - If the new installation does not have IBM 3340 disk units available, the unit definition in all modules accessing the container park file will need changing, as will the randomizing routines for recording placement in this file.

MDHC have run demonstrations of the CONICS system in several areas of the world: Germany (2), New Zealand (2), U.S.A., and South Africa. They do this by setting up a virtual IBM DOS/VS/CICS environment on local IBM OS/VM computer, then installing the Liverpool system on it.

The CONICS system is currently installed in two other terminals:

Bremerhaven	- identical to the Liverpool System. Operations are 60 percent rail which are handled by the system like a ship.
Houston	- Liverpool system with changes in the billing facilities.

Three other container operations are interested in the USA. These will be handled by Houston, acting as the agent for MDHC.

Melbourne is using the CONICS system specifications to build a system of their own on an ICL computer.

III.6.3 Documentation

A copy of the System and Implementation Guide for CONICS (an IBM publication) was obtained which gives a comprehensive coverage of:

- the system overview;
- the container port procedures;
- the system description;
- the data file content;
- the implementation of the system.

APPENDIX II

TERMINAL MANAGEMENT SYSTEM

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1. INTRODUCTION

Objective

The contract between CP Limited and Transportation Development Centre which governs the study specifies the following objective:

> "The main purpose of this project is to design an optimal terminal applicable to major Canadian cities having due regard to land values and making appropriate use of new technology ... and data systems."

Achievement of the Objective

Appendix I documents a systems approach to designing intermodal road-rail facilities with capacities of 100,000 to 400,000 units per year using both existing and new technology.

The 'worked example' Cost Model in Appendix III presents design proposals for the short-term expansion of a typical major terminal, Terminal 'X'. These short term changes will be made before the decision as to the type of the terminal for the medium to long-term is made. This terminal will experience a substantial traffic growth and a swing from trailers to containers over the next 5 years.

This volume documents the data systems aspect of this approach. It identifies the functions required for a computer-based Terminal Management System (TMS) which will be needed to achieve these expansion goals, with recommendations for implementation in manageable phases as throughput grows and the physical facilities are expanded.

2. CURRENT OPERATIONS

2.1 Intermodal Operations

2.1.1 Terminal Network

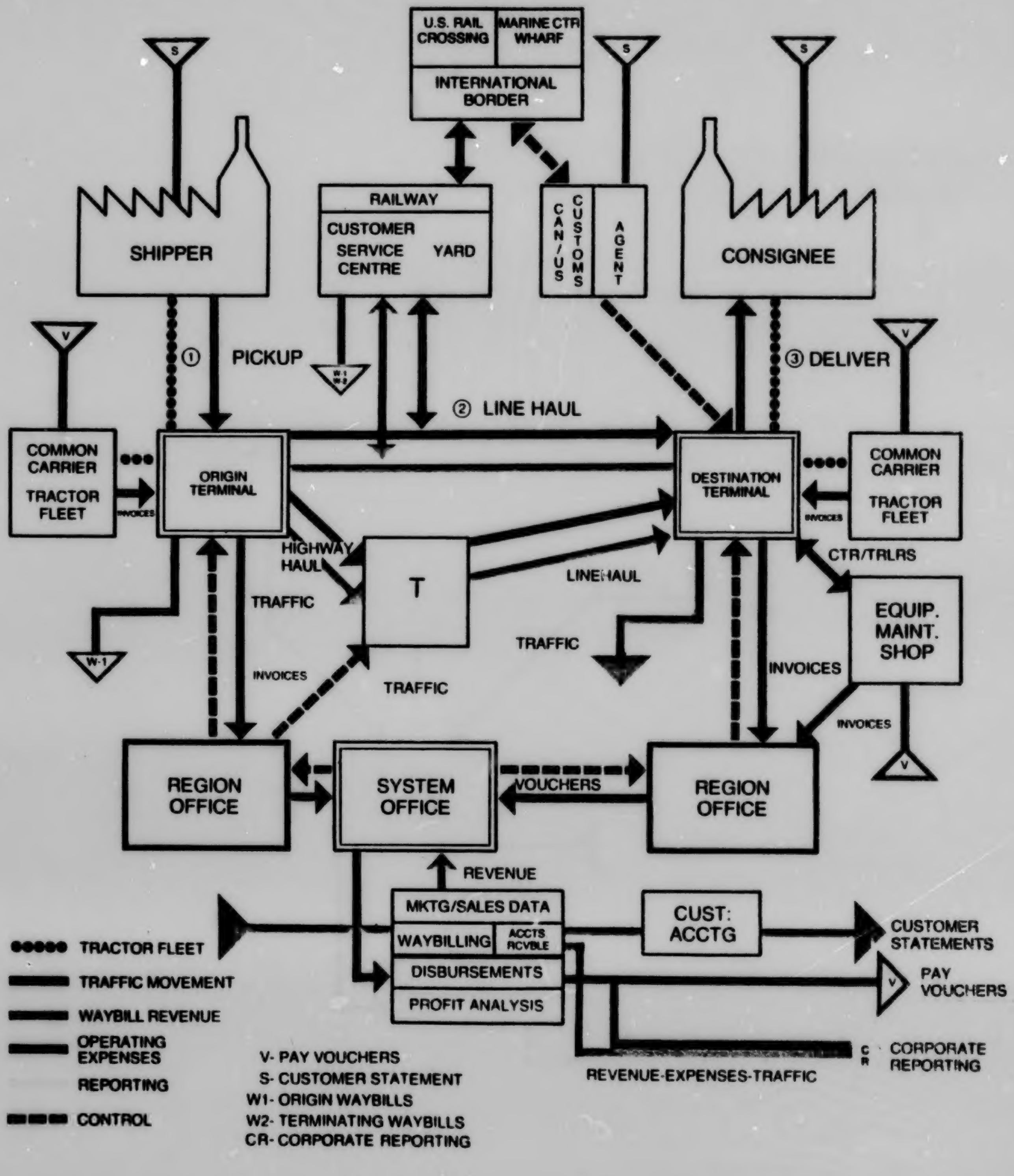
Figure 3.1 presents a dynamic view of the intermodal system in operation in terms of four major flows, colour-coded to show:

- intermodal traffic through the road, terminal and rail networks (red);
- revenue created by the waybilling process, flowing through to accounts receivable (blue);
- expenses created by invoices from contractors, flowing through the vouchering procedures (green);
- the reporting of traffic statistics from the terminals, joining the revenue and expense information as input to profit analysis procedures in order to calculate profitability measures (yellow).

This network is managed as 5 geographic regions, controlled centrally by the system headquarters office in Montreal as indicated by the broken black lines in Figure 3.1.

The four flows are described in Sections 2.2.1 to 2.2.4 and are based upon the work handled at a typical major facility. This site is illustrated in Figure 3.2.

Figure 3.1 Intermodal Operations — Typical Work Flows


U.S. RAIL CROSSING
MARINE CTR WHARF
INTERNATIONAL BORDER
S
S
S
SHIPPER
RAILWAY
CUSTOMER SERVICE CENTRE
YARD
CAN/US CUSTOMS
AGENT
CONSIGNEE
V
① PICKUP
W-1 W-2
② LINE HAUL
③ DELIVER
V
COMMON CARRIER
TRACTOR FLEET
INVOICES
ORIGIN TERMINAL
DESTINATION TERMINAL
INVOICES
COMMON CARRIER
TRACTOR FLEET
HIGHWAY HAUL
T
LINEHAUL
CTR/TRLRS
TRAFFIC
EQUIP. MAINT. SHOP
W-1
TRAFFIC
INVOICES
TRAFFIC
INVOICES
INVOICES
V
REGION OFFICE
SYSTEM OFFICE
VOUCHERS
REGION OFFICE
REVENUE
MKTG/SALES DATA
WAYBILLING
ACCTS RCVBLE
DISBURSEMENTS
PROFIT ANALYSIS
CUST: ACCTG
CUSTOMER STATEMENTS
V
PAY VOUCHERS
CR
CORPORATE REPORTING
REVENUE-EXPENSES-TRAFFIC
TRACTOR FLEET
TRAFFIC MOVEMENT
WAYBILL REVENUE
OPERATING EXPENSES
REPORTING
CONTROL
V- PAY VOUCHERS
S- CUSTOMER STATEMENT
W1- ORIGIN WAYBILLS
W2- TERMINATING WAYBILLS
CR- CORPORATE REPORTING

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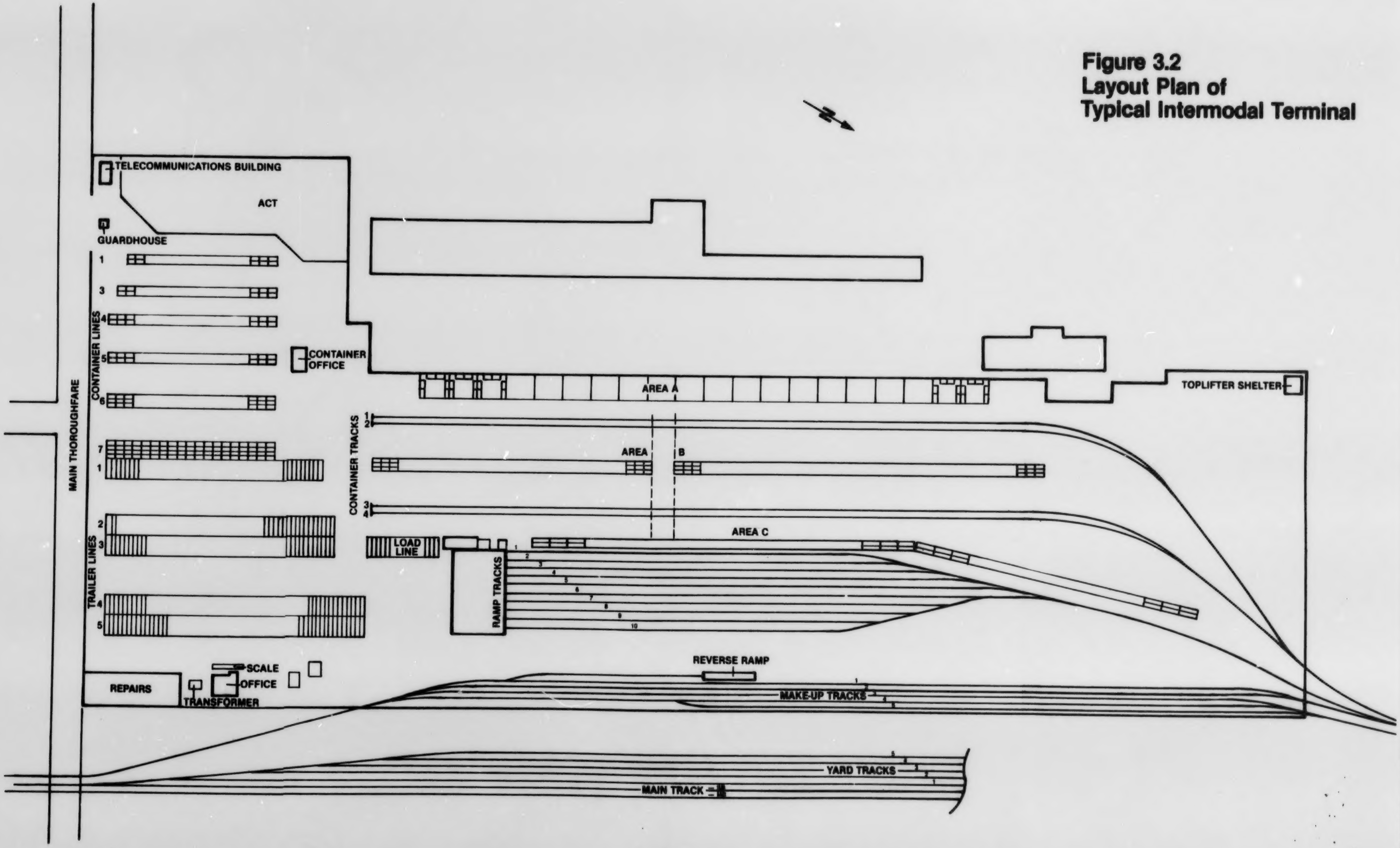

TELECOMMUNICATIONS BUILDING
ACT
GUARDHOUSE
MAIN THOROUGHFARE
CONTAINER LINES
1
3
4
5
6
7
CONTAINER OFFICE
TRAILER LINES
1
2
3
4
5
LOAD LINE
RAMP TRACKS
1
2
3
4
5
6
7
8
9
10
CONTAINER TRACKS
1
2
3
4
AREA A
AREA
B
AREA C
TOPLIFTER SHELTER
REVERSE RAMP
MAKE-UP TRACKS
1
2
3
4
5
REPAIRS
SCALE
OFFICE
TRANSFORMER
YARD TRACKS
5
4
3
2
1
MAIN TRACK

Figure 3.2
Layout Plan of
Typical Intermodal Terminal

2.1.2 Terminal Facilities

This 50-acre site accommodates adjacent container and trailer terminals and handles the full range of intermodal traffic. In 1980, this site handled over 155,000 shipments at a peak rate of 430 per day.

Each facility has 3 working areas with which to forward shipments outbound to rail from the shippers at the origin and to distribute traffic inbound from rail at the destination:

. Road Interface: The dispatch office and the inspection/weigh scale area are the central points for the physical interchange of containers and trailers with road transport. They are located in and around the terminal office. The dispatch office provides trailers and containers from inventory to shippers and expedites the pickup and delivery of shipments. The inspection/scale area:

  - inspects the condition of trailers and containers upon entry and exit;
  - Weighs entering shipments (usually only trailers);
  - exchanges documents with the drivers.

. Yard: The site provides ground storage for 383 trailers and 1430 TEU. This site is largely occupied by inbound traffic awaiting clearance and delivery. Empties are also stored in the terminal. This terminal also has an empty storage location 1½ miles away which regularly stores 700 or more marine containers.

. Rail Interface: The terminal track areas are the active work areas for transferring trailers and containers between the railcars and the ground.

At this site, there are 10 ramp tracks with an average length of 1,100 feet and which can hold 183 57-foot 7-inch piggyback cars. The container area has 4 tracks with a capacity of 66 - 94-foot 8-inch nail cars.

. Administration: The terminal office is the document processing center for traffic in transit through the terminal. This office:

  - exchanges waybills with the railway upon train arrival and departure;
  - controls the release of inbound shipments to customers (international and import traffic);
  - tracks the location and condition of all trailers and containers under its control;
  - expedites maintenance and repairs.

. Traffic Movement

Road Access: A single gate provides access to the street. A gate guard controls the exit of containers and trailers from the site.

Rail Access: All rail traffic arrives at and departs from the adjacent yard. The yardmaster orders railcars into and out of the terminal tracks as required by switch engine using the make-up tracks as a buffer area in which to store railcars awaiting loading, and to line-up trains for departure.

Yard Moves: The trailer ramp tracks are stripped by hostler tractors equipped with hydraulic 5th wheels which drop the trailers in the arrival area. For delivery, the road vehicle tours this area and hitches to the trailer, then proceeds to the inspection/scale area before exiting.

For outbound traffic, the pickup vehicle drops the trailer in the load line after being received at the inspection/scale area.

Inbound containers are stripped by 3 toplifters. Import traffic is grounded to await clearance. Domestic Containers are loaded onto trailers and hostled to the trailer terminal for delivery.

Outbound containers are moved railside by the pickup tractor (or hostler, in the case of domestic containers on chassis) and loaded directly onto railcars.

2.1.3 Traffic Flow

Figure 3.1 illustrates the three segments of an intermodal journey as follows:

- Pickup: Load the shipment into a container or trailer; transport it to the origin terminal by road; load it outbound to rail.
- Linehaul: Move the shipment over the rail network to a destination terminal close to the consignee's location if it is a domestic shipment, or to a marine terminal or US rail connection if it is a foreign shipment.
- Deliver: Receive the shipment inbound from rail, and transport it by road to the consignee.

Figure 3.3 presents a schematic diagram of the procedures currently in force at the terminal to handle the pickup (outbound) and delivery (inbound) segments of this intermodal journey, as are the major operating areas of the terminal mentioned in the previous sections.

This figure shows the complete set of steps for handling Plan II door-to-door domestic shipments at the trailer terminal using railway-owned equipment stored empty at the terminal. The complete processing sequence for a domestic Plan II shipment can be traced from shipper to consignee.

With a slight modification, it also shows the ramp-to-ramp trailer traffic at the trailer terminal (no empty handling necessary and import/export traffic at the container terminal (box IB7 does not apply).

The individual steps shown on Figure 3.3 are as follows:

1. Pickup: Outbound to rail at origin terminal

Road Interface

OB1: The shipper requests a unit.

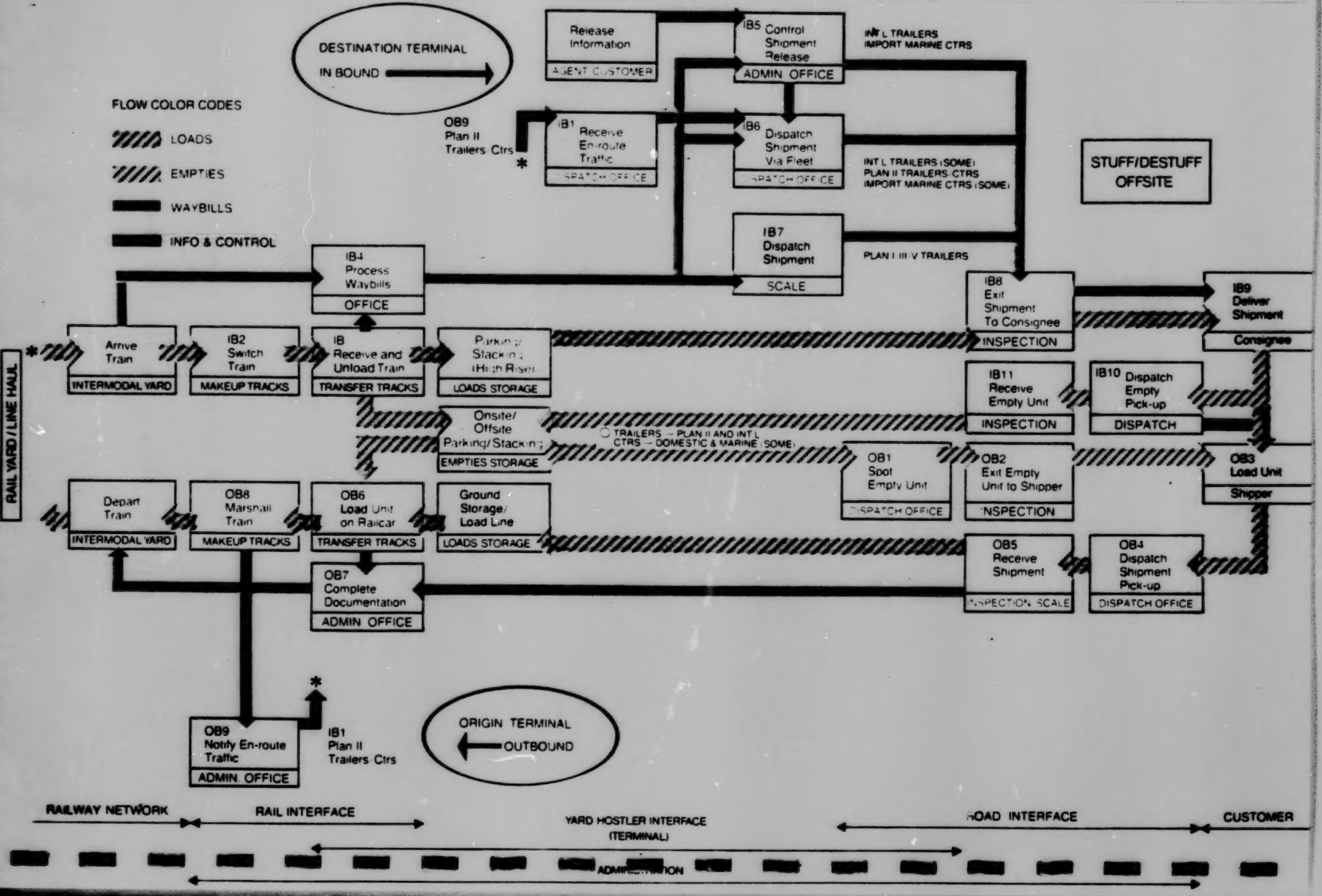
OB2: The dispatcher sends an empty trailer or container from his inventory - it is inspected at the exit.

Customer

OB3: The shipper loads the unit and prepares a bill of lading.

OB4: The dispatcher picks up the unit upon request.

Figure 3.3 Terminal Operating Procedures


DESTINATION TERMINAL
IN BOUND
FLOW COLOR CODES
LOADS
EMPTIES
WAYBILLS
INFO & CONTROL
Release Information
AGENT CUSTOMER
IB5 Control Shipment Release
ADMIN OFFICE
INT'L TRAILERS
IMPORT MARINE CTRS
OB9 Plan II Trailers Ctrs
*
IB1 Receive En-route Traffic
DISPATCH OFFICE
IB6 Dispatch Shipment Via Fleet
DISPATCH OFFICE
INT'L TRAILERS (SOME)
PLAN II TRAILERS CTRS
IMPORT MARINE CTRS (SOME)
STUFF/DESTUFF OFFSITE
IB7 Dispatch Shipment
SCALE
PLAN I III V TRAILERS
IB4 Process Waybills
OFFICE
IB8 Exit Shipment To Consignee
INSPECTION
IB9 Deliver Shipment
Consignee
RAIL YARD / LINE HAUL
Arrive Train
INTERMODAL YARD
IB2 Switch Train
MAKEUP TRACKS
IB Receive and Unload Train
TRANSFER TRACKS
Parking/ Stacking (High Rise)
LOADS STORAGE
IB11 Receive Empty Unit
INSPECTION
IB10 Dispatch Empty Pick-up
DISPATCH
Onsite/ Offsite Parking/ Stacking
EMPTIES STORAGE
TRAILERS — PLAN II AND INT'L
CTRS — DOMESTIC & MARINE (SOME)
OB1 Spot Empty Unit
DISPATCH OFFICE
OB2 Exit Empty Unit to Shipper
INSPECTION
OB3 Load Unit
Shipper
Depart Train
INTERMODAL YARD
OB8 Marshall Train
MAKEUP TRACKS
OB6 Load Unit on Railcar
TRANSFER TRACKS
Ground Storage/ Load Line
LOADS STORAGE
OB5 Receive Shipment
INSPECTION SCALE
OB4 Dispatch Shipment Pick-up
DISPATCH OFFICE
OB7 Complete Documentation
ADMIN OFFICE
OB9 Notify En-route Traffic
ADMIN. OFFICE
IB1 Plan II Trailers Ctrs
ORIGIN TERMINAL
OUTBOUND
RAILWAY NETWORK
RAIL INTERFACE
YARD HOSTLER INTERFACE (TERMINAL)
ROAD INTERFACE
CUSTOMER
ADMINISTRATION

Road Interface

OB5: The unit is inspected, weighed and accepted into the terminal. A revenue waybill is created from the bill of lading.

Yard/Administration

OB6: The unit is taken track-side and loaded onto a rail car.

OB7: The car movement waybills are created for each rail car.

Rail Interface

OB8: The train is lined up and switched out of the terminal to the nearby rail yard. The waybills go with train conductor.

OB9: When the train departs, the origin terminal telexes enroute traffic to each destination terminal.

2. Deliver: Inbound from rail at destination terminal

Rail Interface

1B1: Enroute traffic is logged from the telex (1-4 days in advance of arrival), train consist gives 8-12 hours advance notice of actual arrival.

1B2: Rail cars are pushed into the terminal from the rail yard.

1B3: The train is stripped by hostlers (trailers) or toplifters (containers) and the units are grounded in the yard.

Yard/Administration

1B4: Waybills from the conductor are matched and distributed for delivery dispatch.

1B5: International trailers and import containers are held until cleared by customs and the shipping agent. They may be delivered by a shipper or agent dispatched tractor, or by the terminal dispatcher (IB6).

Road Interface

IB6: The dispatcher expedites the delivery of Plan II traffic as soon as possible. He also dispatches other traffic upon request.

IB7: For Plan I, III and V ramp-ramp services, the customers deliver their own units.

IB8: The unit is inspected upon exit and any required payments are made.

Customer

IB9: The unit is emptied at the consignee's dock.

Road Interface

IB10: Return to the terminal once made empty. Some containers and trailers may be expedited by the dispatcher.

IB11: The unit is inspected and received into terminal or remote empty storage.

Management of Railcars

The container and trailer terminals each control their own inventories of railcars.

Each day, the Assistant Terminal Supervisor (ATS) uses the trains consists received 8 to 12 hours in advance of each train's arrival to formulate short-term operating plans. When the cars have been placed in the terminal tracks, the ATS logs the contents of each track in an inbound sheet or log book which then becomes the basis for controlling, stripping, and informing the office of which traffic has arrived.

The railcars received in the morning become the inventory of outbound cars for that evening's loadings. These cars are allocated to destinations according to the ATS' estimates of the day's traffic which is based upon traffic from regular customers and modified to reflect seasonal trends, ship schedules, etc. Containers are loaded directly from chassis as they arrive while trailers are dropped in a 'load line' and loaded by hostler tractors.

The ATS records the actual loading of containers and trailers on railcars in an outbound sheet or log book with information transcribed from the inbound data.

Permanent records of each day's traffic are assembled by a clerk who files the completed sheets each day, or transcribes them onto a spread sheet (e.g. the daily operations sheet used in the trailer terminal).

Documents and Clerical Procedures

With the exception of the waybilling and car/container/trailer tracing inquiries, all of the operating procedures are manual and all documents are handwritten.

For example, the information on an inbound Plan II trailer passes through 8 steps on its way from rail car to consignee and back to empty storage. These procedures involve the terminal operating staff, the waybill, up to 10 internal forms or logbook entries, and two or more Xerox copies of forms with insufficient information. The terminal retains 8 of these forms in its files for inquiry, checking and reporting purposes.

Overall, a total of 33 document forms are used in the trailer terminal - 15 are external forms (such as the waybill or bill of lading) and 18 are internal worksheets (such as the ramp foreman's book or in-bond book).

Inventory Tracking

At any given time, a major terminal can be dealing with 1,500 or more trailers, containers and chassis with a varying:

- ownership - owning railway, shipping lines, other railways;
- status - empty, loaded, bad order;
- location - linehaul, yard, repair, shipper, consignee.

The tracking procedures for trailers and containers are as follows:

Linehaul

Train consists give no information concerning trailers or containers. As each train leaves a terminal, a clerk notifies each destination terminal of the traffic enroute to it by telex (OB9). This information is received and logged by the destination terminal (IB1).

Trailer Terminal

Inbound Plan I, III, V (i.e. non railway-owned) trailers are logged by the clerk at the inspection/scale area in order to record their release to the outside carriers.

The railway-owned equipment (in Plan II service) is tracked by the dispatch office as part of the expediting function using a display board and cards which are color-coded by trailer type (dry van, stake and rake, etc.). The board is sectioned to follow movement:

- enroute - on rail, approaching the terminal;
- on delivery - arrived, being delivered or spotted for loading;
- for pickup - at customer awaiting return to terminal;
- empty - in terminal awaiting next trip.

The dispatcher creates inventory control cards from the telexes sent by the forwarding terminals, slotting them initially into the enroute board. Each card is shifted to follow delivery, pickup, etc., and is filed in the terminal records when the trailer finally leaves by rail.

Intermodal trailers are tracked by the in-bond clerk through entries in his in-bond book as part of the release control function.

Container Terminal

A similar board and card system tracks import containers through release, control, pickup, delivery and into empty storage. In this case, the cards are coloured by ownership (ACL, Mitsui, etc.)

If a container leaves the terminal and returns to empty storage, a new card may be created, particularly at this terminal where many empties are kept in a remote location.

Chassis are assigned to a given terminal for pickup and delivery work and rarely travel on rail. Each dispatcher keeps a strip record of each chassis in inventory and writes the container number on the tag when each chassis is in use.

System-wide Tracking

The equipment utilization section of the system office oversees the distribution of equipment over the entire network and orders terminals to forward empty equipment to meet expected traffic (e.g. ship arrivals) and to balance equipment distribution.

The necessary tracking data for trailers and Domestic Containers is transcribed each night from the display board in the trailer terminal dispatch office and sent by telex to Montreal. Train consists are used to track rail cars.

2.1.4 Revenue

Intermodal services charges fall into two classes, transportation and miscellaneous.

Transportation Charges

Transportation charges are waybilled at the terminals according to railway practice and tariffs using the computer-based Fastway system, an interactive system. On-line access for data entry, printing and inquiry is provided by visual display units (VDU's) and printers installed in the customer accounting centers, region offices, the system office, and at all terminals.

- The revenue waybill is created for the container or trailer when it arrives at the original terminal (OB3). The charges depend upon the sales plan, distance, commodity, etc.
- Car movement waybills are created after the rail cars are loaded (OB7).
- Waybills are printed and assembled for inclusion in the train consist package travelling with the conductor (OB8).
- At the destination terminal, the waybill is terminated via Fastway when the shipment is delivered or collected, and after any extra charges (delivery, detention, etc.) have been assessed (IB8).

Fastway automatically feeds the waybill data into the accounts receivable system.

Miscellaneous Charges

Non-transportation charges are assessed by the terminal as they occur and are reported to a customer accounting office for entry into accounts receivable. Typical miscellaneous charges cover such things as storage of empty marine containers, cleaning, repairs, supplies for special containers, etc.

Customer Accounting

The customer accounting centres handle the following accounts receivable activities:

- Monitoring of waybilling activities at the terminals (shipment rating, credit, etc.). Accounting copies of the waybills are automatically printed for this purpose.
- Entering of customer statements.
- Printing of customer statements and sending them to the customers.
- Accepting payments from customers and entering data into the accounts receivable system.

2.1.5 Expenses

Charges

Direct operating expenses incurred by the terminals are processed by the manual vouchering system. The main classes of charges are:

- transportation - all trucking activity at terminals is done on contract for:
  - terminal dispatched pickup, delivery and highway haul;
  - the hostling of trailers and containers on chassis within the terminal;
- repair and maintenance - contract and charges for the repair and maintenance of owned and operated trailers, containers and chassis;
- miscellaneous - travel expenses, cleaning, rent, etc., at terminals and region and system offices.

Vouchering of Terminal Expenses

The vouchering process involves the following steps:

- Contractors send invoices to the terminals.
- Invoices are verified using terminal records. The dispatcher verifies the transportation charges using waybills and inventory control cards.
- Verified invoices are collected at the regional offices and approved by the regional management. Vouchers (cheque and statement forms) are prepared and sent to the system office.
- System office management gives final approval, then sends the vouchers to disbursement accounting for payment.

2.1.6 Reporting

The following information provides the data needed to monitor the financial and operational efficiency of the intermodal activities.

Profitability

Each month, the railway profit analysis group provides profitability reports to the railway and management based upon the revenue, expense and traffic information prepared by the system office as follows:

- The revenue information is retrieved from the railway marketing and sales computer database which is an accumulation of the waybill data from the Fastway system.

- Direct expenses (contract charges for transportation, equipment repair and maintenance and miscellaneous charges) are tabulated from the manual system office records of approved vouchers.

- Linehaul expenses levied by the railway are based upon ton-miles of linehaul traffic. The system office calculates this value by correlating traffic reports submitted by each terminal each month. These reports are summaries of the origin, destination and weight information on revenue waybills for shipments forwarded by the terminal in the period.

Activity Analysis

Intermodal services marketing and sales personnel also receive an analysis of traffic by customer, rail corridor, commodity, etc., from the railway database.

Operating Performance

The system office tabulates various elementary measures of contractor performance from the vouchers presented for transportation charges.

The documents and voucher copies for equipment repair and maintenance charges are retained by the Manager of Equipment and accumulated for each piece of equipment. This collection of information permits the monitoring of costs for each individual item, the survey of repair and maintenance patterns, and the tracking of retrofit and modification programs.

3. OVERVIEW OF TERMINAL MANAGEMENT SYSTEMS

3.1 Objectives

An analysis of the operating cost factors at both the terminal and system level showed that the primary goals in designing facilities should be to:

- maximize the throughput capacities of terminals in order to get the best productivity out of the plant and equipment across the system as a whole;
- minimize the operating cost in order to increase the profitability of operations;
- improve the level and flexibility of service so that the customer sees the service as being competitive and reliable.

The challenge, therefore, is to deal with an ever increasing number of shipments with a changing traffic mix while ensuring that each shipment gets from shipper to consignee as expected. At the same time, trailers, containers, railcars and pickup and delivery fleets should be used to maximum effect, investment in terminal facilities should be minimized, and operating efficiency must be increased or at least maintained.

3.2 Terminal Design and Operating Factors

A review of the work being done by some railways (British Rail, SCL, CN) and some marine operations (Brunterm, Liverpool, Rotterdam, Hamburg) shows that in order to meet these challenges, better information management procedures are at least as important as new or improved physical facilities.

While clerical procedures are largely independent of the technology used to move shipments or of the layout of the yard (for instance, the same trailer terminal procedure handles Plan II shipments for both trailers and containers), the link between these factors is such that each design option influences:

- how much information must be kept;
- where and when the information is collected;
- where and when the information is available.

A design option is, therefore, only viable if the information is there to support it.

It is evident that the increases in throughput and changes in traffic mix will lead to terminals with:

- more access gates, inspection areas and scales at the road interface; each handling all types of traffic as compared to the existing split between trailer office (domestic/international) and container office (import/export);
- a tighter control of access to the yard area by road vehicles;
- a more efficient fleet of carrier-owned and operated tractors for pickup and delivery;
- more frequent train arrivals and departures;
- more productive terminal tracks for the loading and stripping of trains;
- more container tracks and fewer trailer ramps;
- more use of captive equipment to service the terminal tracks (e.g. toplifters, gantry cranes, straddle carriers);
- a larger yard area capable of storing a larger inventory of trailers, containers, chassis and railcars - partly due to an increase in traffic and partly due to a larger carrier-owned equipment fleet in Plan II service;

- a better segregation of the ground storage areas with a clearer identification of yard locations and grouping of trailers and containers by destination, status, ownership, etc.;

- a higher density storage of containers;

- more off-site storage areas to hold empty equipment, low-priority shipments, etc.

As the pace of activity increases, it will become necessary to tune the operating procedures for the increased throughput at minimum cost through:

- the faster delivery of inbound traffic (Plan II in particular);

- the tighter coordination of pickups and deliveries;

- more dynamic control of pickup and delivery activities;

- longer range planning of railcar trailer and container usage;

- more frequent turnover of terminal tracks;

- the faster resolution of inquiries;

- the earlier detection of delays and errors.

3.3 Evaluation of Current Procedures

With the exception of waybilling and car/trailer/container tracing, all of the present terminal operating procedures are manual. This section evaluates some aspects of terminal operating practices in each working area of the terminal.

3.3.1 Traffic Flow

Many delays are experienced by traffic moving inbound and outbound through the terminal as a result of a lack of foreknowledge about traffic and shipments.

3.3.2 Inbound Traffic

Tracking of Enroute Traffic

Train consists and enroute messages received by the terminals are not cross-checked or otherwise followed-up. Any traffic which gets lost or delayed on the rail network is detected only by customer inquiries and complaints.

Arrival at Terminal

The terminals are part of the rail network but get little useful information from rail operations. Train consists contain no useful information about trailers and containers which limits the terminals' ability to plan the stripping of the loaded trains (IB1). The enroute messages sent by the origin terminal (OB9) to the destinations (IB1) identify trailers and containers, but there is no convenient way of obtaining waybill information from Fastway in groupings relevant to train, arrival day, etc. The first usable knowledge of inbound traffic is, therefore, the waybills arriving with the train conductor (IB3) which must be checked against the ATC's track sheet or the ramp foreman's book (IB4) before notification and dispatching can start (IB5, IB6, IB7). This lack of knowledge tends to reduce service levels by lengthening the delivery times of sensitive domestic traffic, especially Plan II shipments.

Delivery (OB8)

No record is kept of where deramped trailers have been parked in the arrivals area (IB3). The tractors collecting grounded shipments must tour the yard to find their loads. This practice is manageable now but will lead to congestion and lower fleet productivity as domestic traffic (trailers and containers on chassis) increases. The pickup of a marine container involves waiting for a yard supervisor to assign a toplifter which can take a considerable length of time since they are both highly mobile.

3.3.3 Outbound Traffic

Receiving Shipments (OB5)

The peak trailer processing rate of 10-15 per hour through the inspection scale area causes queues during the peak period (1500 hours to 1800 hours). These queues are caused partly because of the manual creation of the inspection forms and scale tickets.

Loading of Trains (OB6)

This activity involves close cooperation between the yard supervisor and the toplifter or hostler driver - both are highly mobile. Supervision tends to be sporadic with the toplifter or hostler driver often working on his own initiative or through the tractor driver. This practice can lead to confusion, errors, and inefficient work patterns at times of high activity.

Waybilling of Cars and Shipments (OB7)

This activity cannot be completed until the yard supervisor carries the loading information into the terminal office and the overloading of the VDU's and printers may result as deadlines approach.

Departures (OB9)

The preparation of the train journal and waybill packages required for train departure is labour intensive and involves a mass of paperwork which again leads to errors and delays when deadlines are tight.

3.3.4 Dispatching

Fleet Planning

The daily planning of the size of fleet needed for pickups and deliveries is an approximate process since the dispatcher knows little about the inbound traffic until he gets the waybills from the conductor (IB5) after they have been checked (IB4). The planning of equipment availability is also an approximate process. When the inventory of Plan II trailers or containers runs low, the dispatcher may cover by ordering per diem units - then find units coming in from rail that could have been used instead. The dispatchers often cannot discover what their regular customers are planning to send them each day, despite much time spent on the telephone.

The dynamic control of tractors while out on the road would permit the dispatchers to more closely coordinate pickups and deliveries. At major terminals, radios are installed in a core section of the fleet for this purpose. Otherwise, tractors are essentially out of control while they are out of the terminal.

These factors limit the effectiveness of the planning and operations in the dispatch office and, therefore, tend to reduce fleet utilization and increase transportation costs.

3.3.5 Inventory Control

Manual Inventory Records

The wall-mounted inventory control boards now used to track Plan II and marine traffic will get more unwieldly to use as the terminal activities and inventory levels increase because:

- the physical board size will have to increase, thus taking up more wall space;
- the amount of detail that will fit on a card cannot be expanded;
- the number of different categories of trailers (or number of container owners) is limited by the number of color distinctions possible with cards or tabs;
- the storing of these cards in terminal records will consume space at an ever-increasing rate and storage off-site is not the answer.

When containers or trailers are stored off-terminal, the inventory cards must be duplicated if the board in the dispatch office and the one in the empty annex are not properly updated since:

- the duplicate cards will cause confusion as to the actual location;
- no cards will effectively make the unit unavailable.

As traffic intensity and inventory size increase, conditions in the major rail terminals will approach those now found in the marine terminals. Here, an accurate knowledge of container location and a control over where they are placed are considered to be essential to effective yard operation.

3.3.6 Administration

Reception and Waybilling of Inbound Traffic

The introduction of Fastway has brought gains to waybill processing but has added another form to the processing chain. Before Fastway, the waybill was typed by the billing clerk at the inspection/scale area from bills of lading and weigh scale data (IB3). Now a clerk at the scale creates a scale ticket which is later passed to the billing clerk in a central part of the office for waybilling. This manual procedure reduces the overall gain from the introduction of Fastway.

Document Flow

Documents pass through many hands. For example, the documents for an inbound international shipment pass through 7 steps as the trailer moves from the railcar to the consignee and back to empty storage (IB2-IB11). The paperwork requires processing by 5 clerks. In order to propagate the information, the clerk creating it must physically pass a document to someone else, often a Xerox copy. An efficient processing chain demands that the clerks and supervisors processing a given type of traffic be within a few feet of each other in order to process inbound and outbound traffic quickly, certainly a constraint on future terminal layouts.

Record Keeping

Each clerk keeps a part of the total record needed for his particular function, largely by transcribing data from the waybill and recording new data against it. For example, in the trailer terminal, inbound steps IB5, IB6 and IB7 each control part of the traffic. Each clerk keeps a log of items under his control by splitting inbound inventory records into the inbond book (international), the inventory control board (Plan II), and the record of inbound trailers received (Plan I, III, & V). A total of 18 internal forms are used daily in the trailer office.

Quality of Data

The repetitive transcribing of data implied above takes a lot of time and leads to errors. The records are inherently passive, and are not self-checking for completeness, timeliness or accuracy.

Inquiries and Error Correction

Inquiries are laborious. Access to today's work is easy; however, tracing past events can be very difficult because all terminal records are random by the usual key for such inquiries, ie. container or trailer number.

Verifying Expenses

The dispatch office must 'certify correct' all invoices for the tractor fleet, a labor-intensive process involving an ever-increasing volume of waybills and inventory control cards.

3.3.7 General

Operating Style

The terminals operate on a demand basis, responding to traffic from road and rail as it occurs with little foreknowledge. There is little evidence of anything more than daily planning at the terminals.

Utilization of Equipment Around the Terminal

Only the terminals know their current inventory and traffic demands. Region offices and the utilization supervisor in the system office are responsible for balancing equipment distribution; however, their control is diluted by having to rely on old information (up to 12 hours late) obtained by phone calls. There is little opportunity to improve this situation using current procedures.

3.3.8 Reporting

Periodic Reports

The reporting of terminal traffic and inventories to the regional and system offices is minimal, consisting of simple lists and tabulations. Compilation work is given a low priority and done by the night clerk. Month-end summaries of these reports take a week or more to complete.

The net result is that the feedback of activity and performance to management is simple, slow and inaccurate. The costing and statistics section of the system office has much work in converting these reports into useful information for profitability, activity and performance measurement.

These measures are coarse, essentially at the system level. Reporting at the region and terminal level involves huge amounts of manual calculation and report effort.

Consequently, the terminals have little idea how efficient they are, and the regional offices find it difficult to assess their relative performance.

New Reports

The burden of reporting increases enormously when conditions are changing - such as the current introduction of Domestic Containers. The reporting of this traffic will result in an estimated 20 new report formats being prepared at both the terminals and system office so that management can track the increasing business being carried in these containers and assess its profitability.

Special Reports

Special purpose reporting is rarely done because it requires so much effort. For example, to gather historical inventory data for the capacity study, the research team spent 2 man-weeks searching through the terminal records in the trailer and container offices.

Consequently, quantitative measures (traffic patterns, cycle times, throughput peaks) which would be useful to operating management for long term planning are not available.

3.4 Conclusions

The critical path for processing traffic through the intermodal terminals is an interweave of physical movement and information handling. The foregoing evaluation of these procedures points out the difficulties with the current information handling methods which limit each terminal's ability to anticipate future traffic demands and equipment supply and, therefore, to organize and track operations efficiently. In short, these procedures are liable to become limits to future growth.

The key to removing these restrictions lies in the creation of highly developed techniques with which to gather information and process it quickly so that much better information can be obtained from much less collection and report effort.

A plan for a computer-based terminal management system is, therefore, a vital part of the development of terminal design criteria.

4. PROPOSED APPROACH

4.1 Terminal Management System Requirements

The Terminal Management System supports the primary purpose and activity of an intermodal terminal, namely the interchange of trailers and containers between road and rail. It also supplies information for the other flows (revenue, expenses, and reporting) which are subordinate to traffic flows and derive their information from them.

A prerequisite for the complete support of these functions is the acquisition of timely information regarding the progress of linehaul traffic, such as:

- the location of all rail cars, trailers, containers and chassis;
- the status of these units (good order, bad order, etc,);
- the departure and expected arrival times.

At the level of the individual terminal (the context of this study), the requirements can be expressed in terms of the four functional areas discussed below.

4.1.1 Inventory

Inventory items should be handled on an individual basis in order to:

- record all data relevant to the interchange of trailers and containers between the yard and the road and rail interfaces (i.e. the activities at the inspection/scale area and at the terminal tracks);
- track the location of each container, trailer, chassis and rail car within the terminal's control (in the yard, in remote storage, while at shipper or consignee, or in the rail yard);
- track the service availability and condition of each item of inventory;
- allocate the placement of intermodal units within the terminal yard according to a yard plan or usage guidelines;
- provide entry and exit information to the waybilling function for waybill creation and termination purposes;

- provide a history of all status and location changes for inquiry, equipment utilization and traffic reporting purposes;
- record the information and control the release of equipment from the terminal (Canada customs, agent's instructions, customer credit status, etc.);
- calculate and record charges associated with the storage of non-railroad owned containers and trailers at the terminals (detention, gate access, etc.);
- calculate and record charges associated with the per-diem rental of containers and trailers from equipment leasing agents, other railroads, container fleet owners, etc.

4.1.2 Road Interface

Customer-oriented road movements of shipments and empty equipment require the following action:

- record the demand for terminal-dispatched road moves from all sources (customers, inbound arrivals, equipment maintenance, etc.)
- provide information suitable for forecasting the dispatching workload and the resulting tractor fleet requirements;
- enable road movements to be dispatched by priority factors (such as traffic plan, availability of equipment, location, etc.);
- calculate the charges associated with the storage of containers and trailers (detention, gate access, etc.);
- record tractor fleet assignments with respect to road movements.

4.1.3 Rail Interface

The grouping and separation of items with respect to trains during the transition between terminal storage and trains is required in order to:

- exchange information with the railroad fleet tracking systems relevant to the movement of intermodal containers, trailers and railcars in trains including:
    - the departure of trains outbound from the terminal to the railroad;
    - enroute status and location during linehaul;
    - the arrival of trains inbound to the terminal from the railroad.

- provide a means of scheduling, monitoring and controlling the activities associated with:
    - train arrivals and the stripping of railcars;
    - railcar loading, train lineup and departure;
- provide information suitable for the planning of rail car usage at the terminal, region and system level.

4.1.4 Communications

The management system should be as accessible to the terminal personnel who are mobile about the yard, such as the ramp foreman and hostler tractor drivers, as it is to the static office staff.

The system should, therefore, provide a direct linkage to the mobile computer terminals for data entry, inquiry and activity control purposes.

4.1.5 Accounting and Performance Measurement

The system should provide information for use by intermodal services and the corporate functions as follows:

- accounts receivable - to bill charges to customers;
- vouchering - to authorize payment of operating changes;
- statistics - to measure operating performance;
- profit analysis - to measure financial performance;
- equipment management - to track fleet operating condition and costs;
- marketing and sales - to track customer and traffic patterns.

4.2 Overview Of The Proposed Terminal Management System

Figure 3.4 shows the Terminal Management System as it would appear to the users at each terminal. The system would have four components organized along functional lines which correspond to the requirements laid out in Section 4.1.

For full implementation, these components would directly support every important activity which may occur in the intermodal terminals. The modular nature of this approach has the advantage of allowing individual features to be installed in a rational fashion as an integral part of an overall planned terminal expansion program. In this regard, the system components are numbered to indicate the installation sequence as outlined in the Tactical Plan presented in Section 5.

4.2.1 External Systems

The railway fleet tracking and waybilling systems would interchange information with the Terminal Management System. These systems are briefly described below. The other systems would receive information either directly (accounts receivable, vouchering and statistics) or indirectly (corporate reporting group), and are mentioned from the point of view of the Terminal Management System.

4.2.2 Waybilling

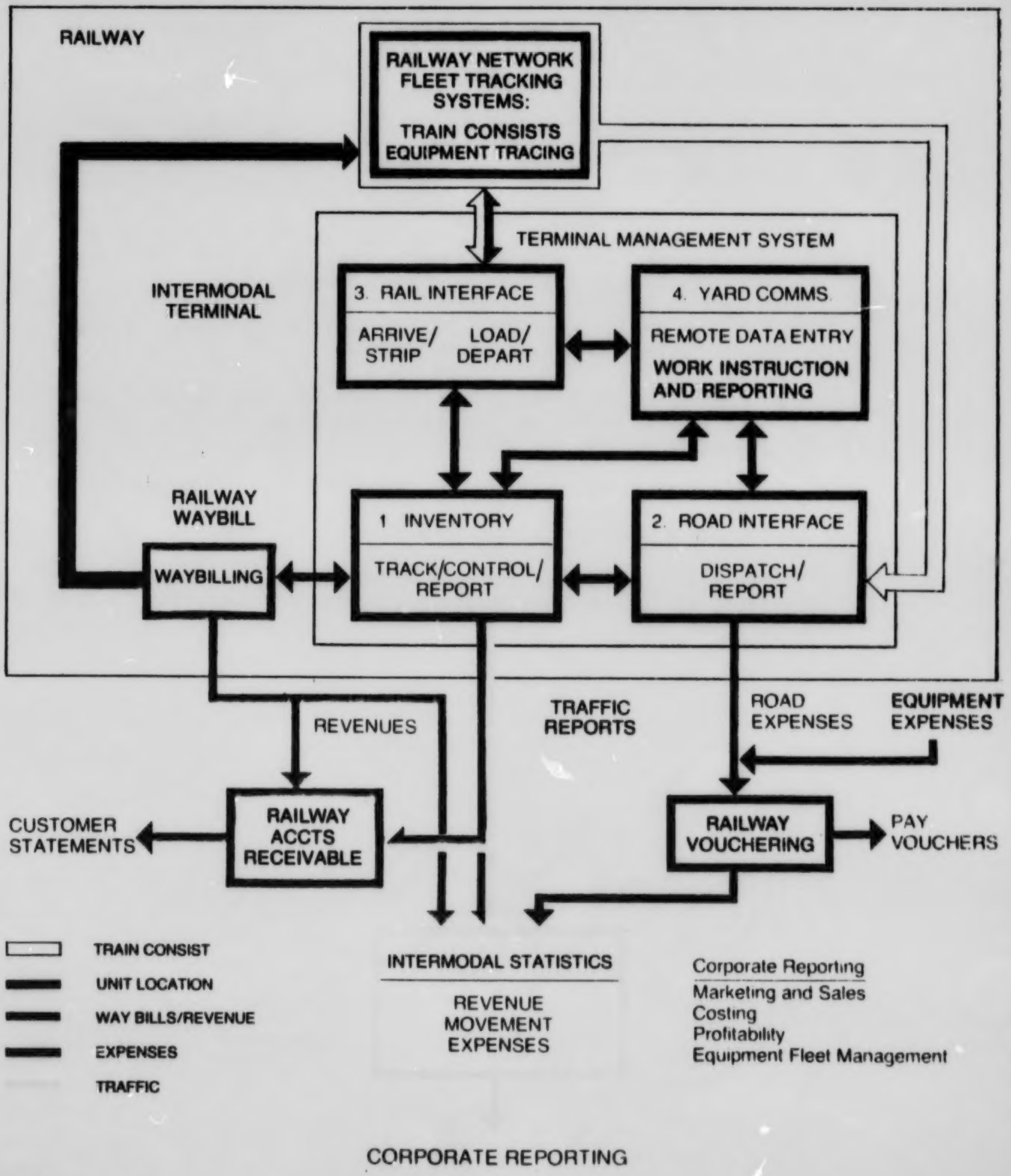
Fastway maintains the following database of current waybill information:

- At the origin terminal, the biller creates a car movement waybill for each outbound railcar and links it to the revenue waybill for each mounted container or trailer.
- At the destination, the biller terminates the car movement waybills upon arrival and the revenue waybills upon delivery.

From the waybill data base, the information would flow in four directions as follows:

- The terminated waybills could be passed immediately to accounts receivable for customer billing.
- This information would be accumulated in a revenue data base from which reports could be retrieved for use by marketing and sales personnel.
- The revenue data would also be used by rail costing and statistics personnel for statistical purposes, and to determine intermodal revenues for profitability reporting.
- the data would be interchanged with the inventory module of the Terminal Management System as described below.

Figure 3.4 Proposed Terminal Management System


RAILWAY
RAILWAY NETWORK FLEET TRACKING SYSTEMS:
TRAIN CONSISTS EQUIPMENT TRACING
TERMINAL MANAGEMENT SYSTEM
INTERMODAL TERMINAL
3. RAIL INTERFACE
ARRIVE/ STRIP
LOAD/ DEPART
4. YARD COMMS.
REMOTE DATA ENTRY
WORK INSTRUCTION AND REPORTING
RAILWAY WAYBILL
WAYBILLING
1 INVENTORY
TRACK/CONTROL/ REPORT
2. ROAD INTERFACE
DISPATCH/ REPORT
REVENUES
TRAFFIC REPORTS
ROAD EXPENSES
EQUIPMENT EXPENSES
CUSTOMER STATEMENTS
RAILWAY ACCTS RECEIVABLE
RAILWAY VOUCHERING
PAY VOUCHERS
TRAIN CONSIST
UNIT LOCATION
WAY BILLS/REVENUE
EXPENSES
TRAFFIC
INTERMODAL STATISTICS
REVENUE
MOVEMENT
EXPENSES
Corporate Reporting
Marketing and Sales
Costing
Profitability
Equipment Fleet Management
CORPORATE REPORTING

4.2.3 Railway Fleet Tracking

This existing feature would be the major external system from the operating point of view. The system would provide two essential elements of information to the Terminal Management System, equipment tracing and train consists.

The TMS would keep a computer database of equipment records for each railcar, trailer and container on the network which would be maintained by three data streams:

- At the start and end of each rail journey, Fastway would update the equipment records as part of the waybill processing as follows:
  - As the waybill is created, Fastway would add a waybill identity to each car, trailer and container equipment record, then would load (cross-reference) the containers or trailers to their conveying cars.
  - At the destination, the car would be 'unloaded' by deleting these cross-references.
- Train consists would update the location information in each equipment record as the trains pass through the railway division points and stations.
- Identification, description, service availability and other status information relevant to each individual unit would be updated whenever changes occur.

The data flow between the fleet tracking and the road and rail interfaces of the Terminal Management System are described in the following section.

4.2.4 Terminal Management System

1. Inventory

This core facility would track, control and report the movement of all intermodal equipment within the control of the terminal. The rail and road interface components could re-use the inventory as a source of information for their own use, and also record location or status changes which may result from the decision-making within these functions.

The inventory would also supply data for waybilling as follows:

- Data collected at the inspection/scale area when a shipment enters the terminal would supply weight and bill of lading information to the Fastway system for use in creating the revenue waybill.
- At the destination, the exit information (such as detention and delivery charges, etc.) could be used to terminate the waybill.

Non-transportation charges (empty storage, cleaning, etc.) would be stored as part of the inventory data until month-end, then transferred to accounts receivable for inclusion in the customer statements.

The history of location and status changes accumulated by the inventory module would be used for the monthly reporting of:

- statistics - the analysis of traffic movements over the system;
- corporate reporting - the costing of linehaul movements;
  - profitability reports.

2. Road Interface

This component would support the dispatchers as they expedite road movements to and from the terminal.

The inventory module would be the data source for making dispatching decisions, and would be used to record the resulting activities and charges. The connection to equipment tracing would provide the dispatcher with a complete view of approaching enroute traffic which should enable better planning of the tractor, container and trailer fleets.

The expense information arising from the tractor fleet assignments would be recorded as it was created, retained until month-end, then fed to the vouchering system to enable invoices from the fleet operators to be verified automatically before payment.

3. Rail Interface

This module would handle the transition between the train-oriented railway fleet tracking facilities and the unit-oriented inventory module.

For inbound traffic, the train consist information (unit and waybill identities, etc.) would be 'arrived' into inventory from the fleet.

For outbound traffic, inventory data would be converted into train consist records as part of the train lineup procedure, then 'departed' to the fleet tracking system when the traffic actually leaves.

4. Yard Communications

A radio communication system would provide mobile terminal personnel (such as ramp foremen and toplifter operators) with access to the modules described above. This equipment would enable these personnel to make inquiries, issue instructions and report activities on the same basis as the office staff.

The equipment would consist of visual display units (mounted in vehicles or hand-held) which can be used to exchange data with the computer system via a radio base station. This station would handle the radio transmissions and a communication processor which would control the digital data flows.

4.2.5 Statistics

In order to measure operating and financial performance, three inputs would be needed as follows:

- Revenue data would be created by the Fastway system aspart of the waybilling process.
- Movement data would be derived from the streams of equipment location and status changes recorded by the inventory components.
- Expense data would be a summary of the invoices paid by the vouchering system.

These information streams would be rearranged into formats useful to management, then passed along to the various systems for reporting at the corporate level.

5. RECOMMENDATIONS FOR IMPLEMENTATION

5.1 Introduction

The new Terminal Management System will convert the working fluid of the terminals from forms and lists to a computer system touching every facet of the operations.

In order to get the maximum benefit from this system, it should be installed in small steps as an integral part of the expansion of the facilities, each part being justified in its own right.

In this regard, several points should be noted:

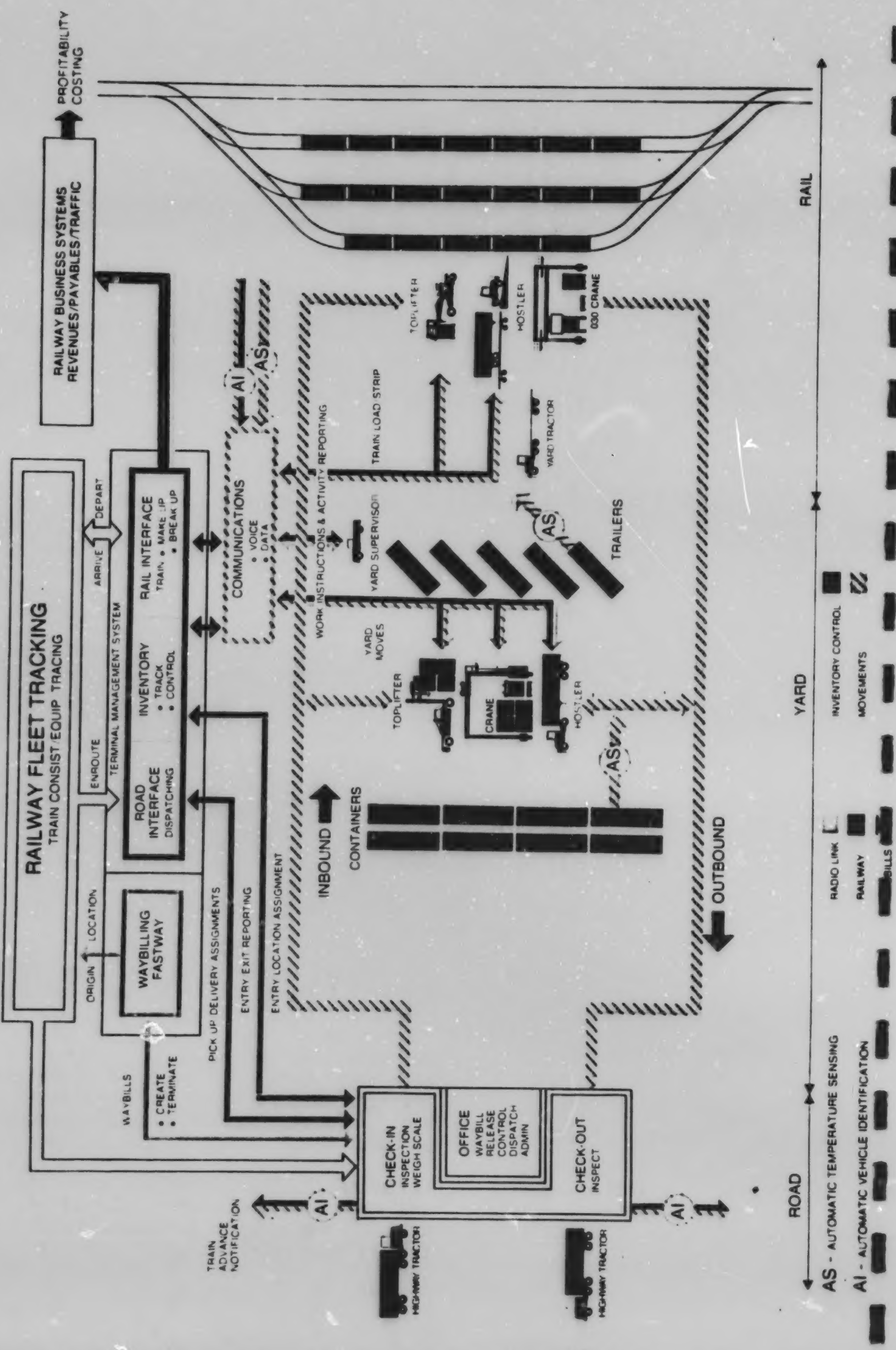
- The facilities described in Sections 5.2 through 5.6 describe system features rather than discrete systems.
- Before discrete systems can be identified, new ways of operating must be devised for each function and a detailed analysis undertaken to determine how best to design and install the necessary facilities.
- There are many systems now in use which could form a basis for the terminal functions. There are also many systems in the planning and development stages which could directly or indirectly provide some of the needed functions.
- Wherever possible, therefore, work on the TMS should build on existing systems, or should be integrated with the development of new systems in adjacent areas.

Figure 3.5 shows how all these systems would relate to a "prototype future terminal".

The Tactical Plan presented below organizes the work on the system features according to priority of need. Sections 5.2 to 5.5 organize the system features which support each functional area into:

- basic support:
  - the passive recording of decisions and activities already taken by the terminal staff;
  - the provision of information geared to the decision-making process; usually displays of pre-determined criteria, e.g. shipment dispatch lists sequenced by consignee.
- active support:
  - the system fully supports all activities and makes decisions where appropriate, e.g. allocates yard positions to containers upon entry.

Figure 3.5 Prototype Future Terminal — System Requirements


RAILWAY BUSINESS SYSTEMS
REVENUES/PAYABLES/TRAFFIC
PROFITABILITY
COSTING
RAILWAY FLEET TRACKING
TRAIN CONSIST/EQUIP TRACING
ORIGIN
LOCATION
ENROUTE
ARRIVE
DEPART
TERMINAL MANAGEMENT SYSTEM
WAYBILLING
FASTWAY
ROAD
INTERFACE
DISPATCHING
INVENTORY
• TRACK
• CONTROL
RAIL INTERFACE
TRAIN • MAKE UP
• BREAK UP
COMMUNICATIONS
• VOICE
• DATA
AI
AS
WAYBILLS
• CREATE
• TERMINATE
PICK UP DELIVERY ASSIGNMENTS
ENTRY EXIT REPORTING
ENTRY LOCATION ASSIGNMENT
WORK INSTRUCTIONS & ACTIVITY REPORTING
TRAIN LOAD STRIP
YARD MOVES
YARD SUPERVISOR
TOPLIFTER
CRANE
HOSTLER
YARD TRACTOR
030 CRANE
TRAILERS
INBOUND
CONTAINERS
OUTBOUND
CHECK-IN
INSPECTION
WEIGH SCALE
OFFICE
WAYBILL
RELEASE
CONTROL
DISPATCH
ADMIN
CHECK-OUT
INSPECT
TRAIN
ADVANCE
NOTIFICATION
HIGHWAY TRACTOR
ROAD
YARD
RAIL
AS - AUTOMATIC TEMPERATURE SENSING
AI - AUTOMATIC VEHICLE IDENTIFICATION
RADIO LINK
RAILWAY
BILLS
INVENTORY CONTROL
MOVEMENTS

5.6 Statistics

In addition, the plan assumes that the prerequisite functional requirements for the railway fleet tracking system are in place, as specified in Section 4.2, so that the full details of the contents and progress of trains carrying intermodal traffic are available to the TMS.

5.1.1 Tactical Plan

In order to get the maximum benefit from the system, it should be installed in small steps, each justified in its own right and built upon previous steps.

1. Install inventory tracking - this function is crucial to:
    - improving the operational efficiency in all areas of the administrative activities;
    - removing the design constraints from the expansion plans;
    - providing a core for further steps.
2. Install the basic support in order to assist decision-making in:
    - road interface;
    - rail interface.
3. Install inventory control.
4. Install the active support of the road interface.
5. Install the active support of the rail interface.
6. Install digital communication facilities in the yard.

The need for steps (1) and (2) is clear and prompt action is essential as part of the overall expansion activities.

Progress in steps (3) to (5) will be influenced by decisions and actions taken for external reasons, for example:

- the handling equipment which will be used for in-yard moves;
- the develoment and enhancement of computer systems that will interface with the TMS functions; YARDEX and vouchering are examples of these systems.

As stated earlier, action on all aspects of the TMS should be timed to profit from work in adjacent projects where possible.

This program applies also to the development of computer-based statistics systems. Since revenue information is already available from the marketing and sales database, this information can be upgraded to suit current needs. The development of systems to produce movement and expense statistics should proceed along with the inventory tracking and vouchering systems respectively.

5.7 Costs and Benefits

5.2 Inventory

5.2.1 Basic Support - Inventory Control

The TMS would maintain a record of every intermodal container, trailer and chassis within the network as follows:

- a permanent record for railway-owned equipment;
- a temporary record for foreign equipment (deleted a fixed period after the unit leaves the network).

It would also record the current location of each unit as it changes. Broad categories could be:

- enroute between terminals - inbound (including expected arrival date);
- inbound - arrived, held in terminal, delivery, pickup;
- in empty storage;
- outbound - delivery, pickup, held in terminal, placed on railcar, departed to rail.

At this stage, only the basic delivery or pickup data, such as time and tractor driver identity, would be recorded by the system.

The inventory records would provide cross-referencing to the central computer databases as follows:

- waybills from Fastway;
- equipment details from EQUIP1, maintained by both train consists and Fastway;
- UMLER maintained by periodic update by AAR and railway sources.

Inventory records would include data items needed to handle the release control of in-bond international and import traffic.

The TMS would record the current status of each unit as it changed:

- state-loaded or empty;
- condition on terminal entry or exit, i.e. damage and maintenance data;
- availability - good/bad order data.

While it is difficult to quantify the benefits to be realized

5.2.2 Active Support - Inventory Control

The inventory control module can become an active participant in expediting the work flow through each terminal by:

- enforcing a logical and complete sequence of events for traffic flows;
- monitoring the performance of required events;
- providing the documents needed for trailer and container internal and interchange movements.

Functions which will improve the work flow are:

- printing trailer and container inspection and interchange documents as part of the entry or exit procedures;
- recording scale ticket data directly from instruments as part of the entry procedure;
- scaling;
- an automatic trailer and container identification system which will provide scale ticket data directly to the Fastway waybilling procedures;
- monitoring location and status changes as they occur and disallowing 'illegal' moves when an incomplete or illogical sequence results (e.g. exit of an unreleased in-bond shipment);
- monitoring the fulfillment of special conditions attached to traffic processing, and signalling exceptions, for example:
    - payment of waybill and miscellaneous charges if the credit rating dictates that they must be paid at the gate before release;
    - maintenance and repairs which must be done before a trailer or container's next use;
    - assignment of a trailer or container to a specific customer.

If the yard areas are identified in detail similar to a mall parking lot, and if each area is assigned a specific use, the inventory module can actively manage the routine aspects of yard use in order to:

- maintain a record of each yard area typically to the level of row and slot and including details of specific use;
- allocate a specific location to each move into the yard from road or rail;
- print location instructions.

These facilities will reduce congestion in the yard area if used to full advantage.

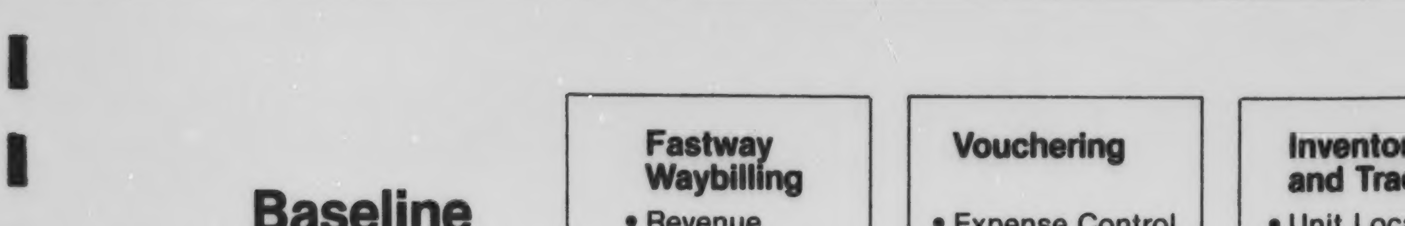
Tractor drivers will not have to tour the trailer area in order to find a trailer because specific directions can be given to them by the dispatcher, scale clerk, or gate guard. Similarly, in the container area, drivers will be able to proceed directly to the correct spot and wait for the toplifter there, rather than congregating around the container office or other waiting areas as at present. An added advantage could be the possible reduction in toplifter travel and waiting time.

5.2.3 Computer Equipment - Inventory Control

The following equipment would be located in a typical terminal. Visual Display Units (VDU's) in order to allow access to the system would be located at:

- the terminal gate - entry/exit control;
- the terminal inspection scale - inspection and document exchange;
- the terminal office - process waybills;
  - control release;
  - record yard moves during stripping, loading relocation;
- the terminal dispatch - record pickup and delivery road moves;
- the region offices - monitor activity;
- the system office - report to utilization control.

Printers at terminals and region and system office locations would provide hard copies of inquiries and periodic or request reports.



5.3 Road Interface

The flexible inquiry facility in the inventory module will allow dispatchers to select sequences and to display inventory data in ways best suited to making dispatch decisions in accordance with whatever priorities are being applied. The inquiry facility will, therefore, supercede the existing inventory control boards and cards.

5.3.1 Basic Road Interface Support

The road dispatch module will extend the computer support of the dispatching functions in order to:

- maintain current identity and availability data for all tractor fleet drivers being used by the dispatch office;
- record requests from customers for pickup or delivery of containers and trailers;
- record instructions for each pickup and delivery, taking the waybill information stored by Fastway if available, and allowing an override as necessary;
- record driver assignment details both in the drivers' record, and in the inventory record (via the inventory module);
- pass details of container and trailer status changes arising from dispatching decisions to the inventory module for updating;
- accumulate a history of driver assignments; reporting periodically for use in verifying invoices from truck brokers and for statistical purposes;
- provide the dispatch supervisors with an overall consolidated view of the linehaul traffic approaching the terminal (principally Plan II and import traffic) in order to forecast dispatching needs and equipment availability. At this level, the information is based upon inventory records showing 'enroute' status to the requesting terminal.

5.3.2 Active Road Interface Support

The facilities mentioned above could be extended to:

- maintain a directory of shipper and consignee names and addresses in each terminal service area. This directory could include location codes, standard journey round-trip times and other data which could help in determining how long a given day's workload may be one of the factors used in gauging tractor fleet size. The inclusion of a location code (similar to a city directory) would help to match pickup and delivery combinations more effectively than is now the case.
- allow the tractor fleet driver data to include the basis of payment and the activity details such that each journey could be costed;
- report assignment and cost information each month to enable the vouchering system to verify contract charges without further work. When the vouchering system is made a computer system, this information will be transferred directly between the systems.
- print pickup and delivery instructions for use by the assigned tractor driver. These instructions could also serve as a turnaround document to record the activity and costing information mentioned above.
- improve the dispatch supervisor's overall view of the line-haul movements by obtaining the current location of approaching traffic from the equipment database maintained by the fleet tracking system. The more accurate information would further improve the short term forecasting of dispatch requirements and equipment availability, and would help to detect potential arrival delays sooner.

5.3.3 Computer Equipment Road Interface

The installation of the inventory module would require at least one VDU in the dispatch office. Initially, the road interface module facilities would use the same VDU(s). As basic and active module functions are added, the dispatch office staff would use the installed VDU's more, probably leading to a requirement for additional units in the dispatch office, especially in major terminals.

5.4 Rail Interface

As with the road interface, the inventory module will provide the primary support for the rail interface activities. Using this module, the terminal staff can interchange individual trailers and containers between terminal (held-in-terminal status) and rail (enroute status).

Inbound traffic received at the terminal inspection/scale area is presently recorded by the scaleman; however, the flexible inquiry facilities will enable the yard supervisors to obtain a continuously updated view of the traffic to be loaded. Similarly, the recording of arrivals from the truck-sheet or ramp foreman's book will make this data immediately available to the dispatchers, inbond clerks and other office staff regardless of location.

At this level of support, the rail car inventory will not be computer based. The records will be manual and will be managed by the yard staff.

5.4.1 Basic Rail Interface Support

This module will make the tracking of rail cars within the terminal more convenient by providing the functions which will handle them into groups and permit the stripping and loading activities to be recorded on a track basis rather than by accessing individual inventory records.

The input for the rail interface functions will be the train consist data obtained directly from the fleet tracking system.

The basic support will provide a convenient way for the terminal staff to line up trains for departure, but will not disturb the established procedures for entering a train consist for a departing train.

Inbound Traffic

When the yardmaster informs the terminal supervisor that an inbound train has arrived and is being placed into the terminal, the rail interface module provides functions to:

- arrive the train or train block into the terminal (the train consist data from the fleet tracking is accessed for this function);
- record the location of each car in the train block (in the terminal tracks, makeup tracks or yard) and update this data to match the switching activities;
- record the stripping activities against the terminal track contents (from 'arrived' to 'held-in-terminal' status).

Outbound Traffic

When the railcars become available for loading, the module will provide the yard supervisor with the functions with which to plan and monitor loading. The module will:

- record the destination and assignments made to the rail cars with the trailers or containers available for loading;
- schedule the loading operations, including the matching of rail cars with the trailers or containers available for loading;
- record the loading moves as they are made ('held-in- terminal' to 'placed-on-rail car' status);
- record changes in rail car location as rail cars are switched out of the terminal tracks to the makeup tracks or rail yard;
- display rail car information by train identity and allow the sequencing of rail cars in order to aid train lineup activities (principally the printing and sequencing of waybills);
- record the departure of each train or train block to the railway. At this level of support, this function is simply a convenient way of providing a mass update in order to change the status from 'placed-on-rail car' to 'enroute'.

Update of Equipment Location and Status Information

- enroute: The equipment tracing module of the fleet tracking system will keep the current location of all equipment (as updated by the train consists - see Section 4.2) without affecting the records kept by the inventory module.
- in-terminal: The rail interface module will affect the inventory records. Each change of location and status caused by an activity around the terminal tracks (stripping, loading and switching) and recorded by the rail interface module will be passed to the inventory module which then updates the individual inventory records.

5.4.2 Active Rail Interface Support

Inbound Traffic

For inbound traffic, the arrival information is already obtainable from the train consist system as described above. The stripping operation can be optimized by enabling the yard supervisors to use the computer to:

- assign yard locations to the incoming traffic using the inventory control module, allowing overrides for special requirements such as urgent shipments;
- print stripping instructions for use by the toplifter and hostler operators.

These functions would guide the stripping activities to follow the current yard plan as much as possible and will provide a turnaround document with which to record actual moves by exception.

Outbound Traffic

Similarly, the yard supervisors can use the computer to:

- print loading instructions to the hostler and toplifter operators, again providing a turnaround document with which to record actual movements;
- line up trains for departure. In addition to displaying rail car information for a particular train and sorting it into switch list sequence, this function will be extended to provide a sequenced railcar list with which to control the sequence of printing waybills from the Fastway system.
- depart the trains and extend the departure processing to include:
    - the printing of train journals;
    - the formatting of train consists or switch lists;
    - the transmitting of train consists directly to the railway fleet tracking system.

5.4.3 Computer Equipment - Rail Interface

The functions specific to the rail interface can all be done using Visual Display Units and printers installed in the terminal office areas, although an additional VDU in the Assistant Terminal Supervisor's office will be necessary at major terminals. The functions which produce the loading and stripping instructions will provide some benefit to communications between the yard supervisors and the toplifter and hostler operators. The logistics of printing the instructions, getting them to the drivers and collecting the results may, however, make this benefit marginal.

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If a radio and computer-based yard communications system is installed, however, the benefits should be substantial because the instructions and reporting cycles will become much more interactive. Section 5.5 deals with this and other aspects of communications systems.

5.5 Communications

Computer systems with VDU's and printers will solve many communication problems between the people working at fixed work stations in the terminal and elsewhere. They will also replace the telex links. It is equally vital to optimise the communications between these people in the office and the highly mobile staff operating in the yard.

The dynamics of physical flow and decision making are key factors in choosing the right system. In intermodal rail terminals, the aim is to:

- move each unit through the terminal the same day it arrives at the road or rail interface;
- turn the railcar inventory around as quickly as possible, usually within one day;
- load arriving units right up to the train departure cut-off time.

These conditions make yard management very interactive. Because the supervisor must know accurately what is in the yard awaiting loading, his plans are estimates and will change frequently depending on what arrives and where it is going. He must promptly tell the ramp tractor or toplifter operators of the new plans as they are formulated.

5.5.1 Direct Mobile Control

The direct control of mobile yard equipment is likely to be required as the activity levels increase. The portable voice radios used in linking the yard supervisors to the office will become inadequate for the projected 1984 traffic volumes. A direct mobile link to the terminal's computer system will be needed to:

- feed detailed instructions to the yard equipment;
- enable the immediate reporting of work done;
- enable the yard supervisors to access stored information while in the yard.

The most promising system for in-yard activity control appears to be mobile digital terminals linking the office yard supervisors and the equipment operators through the computer system. This system will be most effective when used to control captive yard equipment such as container toplifters, trailer ramp tractors and rail gantry cranes. For example, to load trailers, the ramp foreman will make his plans and his prepared instructions in the office via a VDU.

He will use the rail interface system and accesses the latest trailer arrivals from the inventory tracking system (entered at the scale). The hostler tractor will receive the instructions on his cab terminal and immediately report the completion of each move to the computer. Figure 3.6 shows a multi-line display mobile computer terminal installed in a truck cab.

In order to maintain contact when the ramp foreman is out in the yard, a hand-held data terminal could be used. The most suitable one available at present is a combined digital terminal and voice radio. Thus, the ramp foreman's contact with the computer could still be immediate but voice contact is available to solve problems. Figure 3.7 shows a hand-held radio and data terminal.

With this scheme, planning and activity are always based upon the most current information, including the journal clerk in the office who needs the railcar and trailer assignments to complete the waybilling and to prepare train documentation.

Devices of the type mentioned above are currently being used on marine terminals as follows:

- Modern Terminals (Hong Kong) uses Motorola multi-line display IBM-compatible terminals in the driver's cab of straddle carriers and quay cranes.
- Eurokai (Hamburg) is running trials of SNV hand-held portable data transceivers carried throughout the yard by operating personnel. Similar devices are also available from Motorola.

5.5.2 Process Control

Japan is the leader in applying total automation to container terminals. At the Modern Terminals Hong Kong facility, the Hitachi automated container terminal system's central computer issues operational directions through a signal transmitter to rail gantry cranes at the quay and in the yard. The crane lifts the container from a pre-set position and transfers it to another pre-set position. All of this work is done without human intervention by using sensors on the spreader to home-in on the container.

Such sophistication involves very high capital investment in yard handling equipment, computer facilities and process control equipment. It is unlikely to be justifiable in the intermodal terminals foreseen in the near future.

A similar system was proposed by Mitsui to Brunterm in 1978. It stopped short of gantry crane automation, but represented the compelete turnkey implementation of all of the facilities described in this plan.

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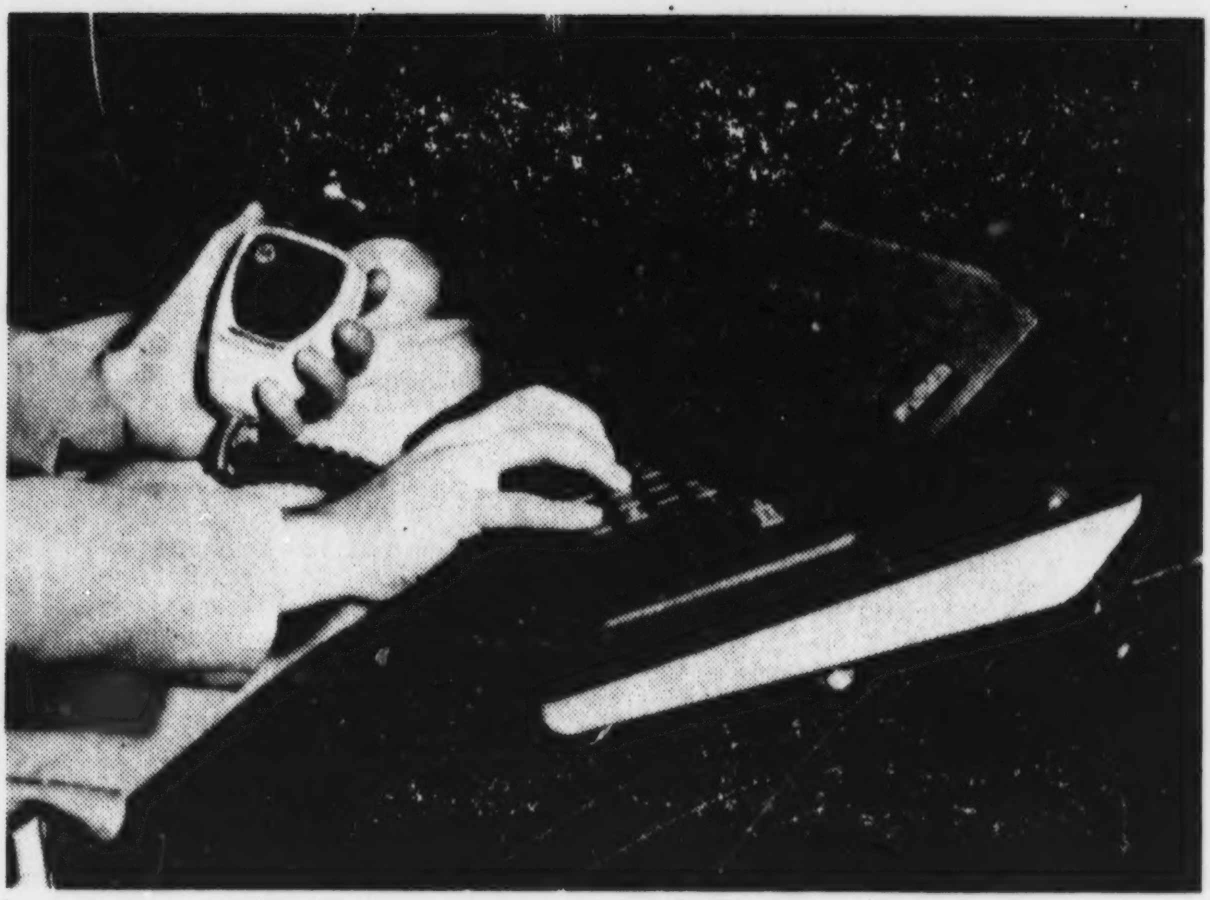
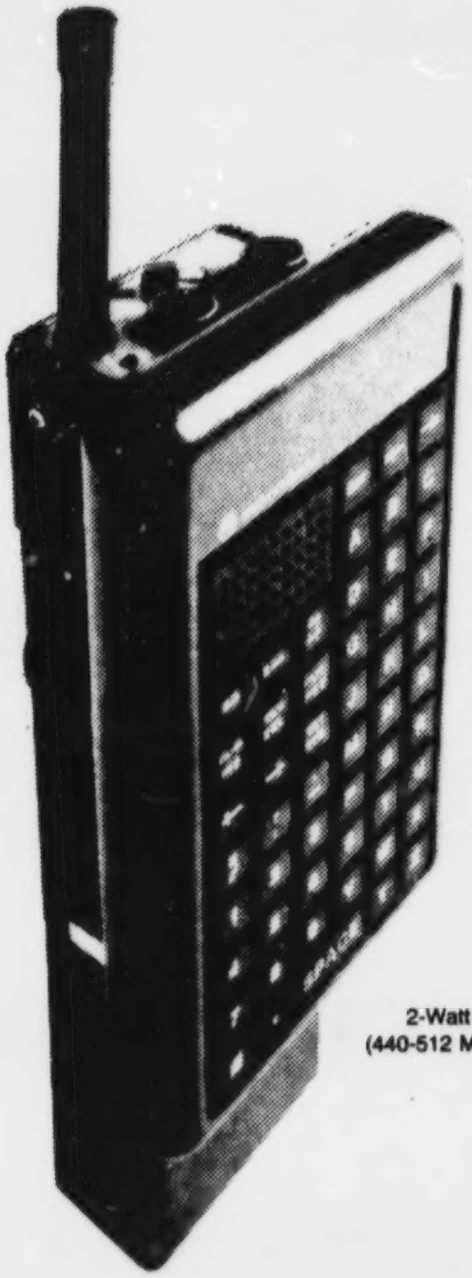
1. INTRODUCTION

Figure 3.6
Mobile Computer Terminal
Multiple Line Display



Annex 4.2.14 presents a summary of these various configurations and a ranking according to working area storage areas (i.e.

Figure 3.7
Combined Radio/Computer Terminal
Hand Held



2-Watt
(440-512 MHz)

The figures used for domestic chassis storage requirements have been estimated. There is insufficient data available with which to

5.6 Statistics

Work on this area should proceed in parallel with the development of the TMS in order to ensure that the requirements of the statistics system are properly recognized by the TMS that will supply the input data. The sources of the major statistical classifications are as follows:

- revenue - input data is already available from Fastway.
- movements - the correct source is inventory rather than Fastway; it can be corrected during the design of the inventory system.
- expenses - input for statistics will come from paid pay-voucher information. A direct connection between road interface and vouchering (for verification of invoices) is not necessary for this activity, so the corporate vouchering system can supply this input from its inception.

1.4 Present Terminal 'X' Land Use

5.7 Costs and Benefits

Figure 3.8 illustrates the tactical plan proposed for the implementation of the Terminal Management System within the framework of an overall intermodal information system. The main phases of the TMS are indicated by the bold outline. Lighter outlines indicate other related system developments which will have a greater impact upon the activities at the system, region or accounting offices.

The new systems to be involved with the TMS are as follows:

. Inventory Control and Tracing

This system will provide a current location record of all containers and trailers in the terminal and will include a status report. The benefits involve a slight reduction in hostling and pickup and delivery costs as well as some clerical savings.

. Handling Equipment Scheduling

This feature will be a natural outgrowth of the Advanced Train Notification and the Inventory Control and Training Systems and should enable the terminal managers to better plan and schedule the priorities, shift schedules, and overtime requirements of the equipment handling equipment and operators, especially for that equipment which handles marine and Domestic Containers.

. Truck Dispatch and Scheduling

This program and its associated communications equipment will enable a closer control to be kept on the pickup and delivery activities by providing a current understanding of equipment location and status to the dispatchers. This closer control of these activities should help to eliminate cross-hauling and will provide some clerical savings as well.

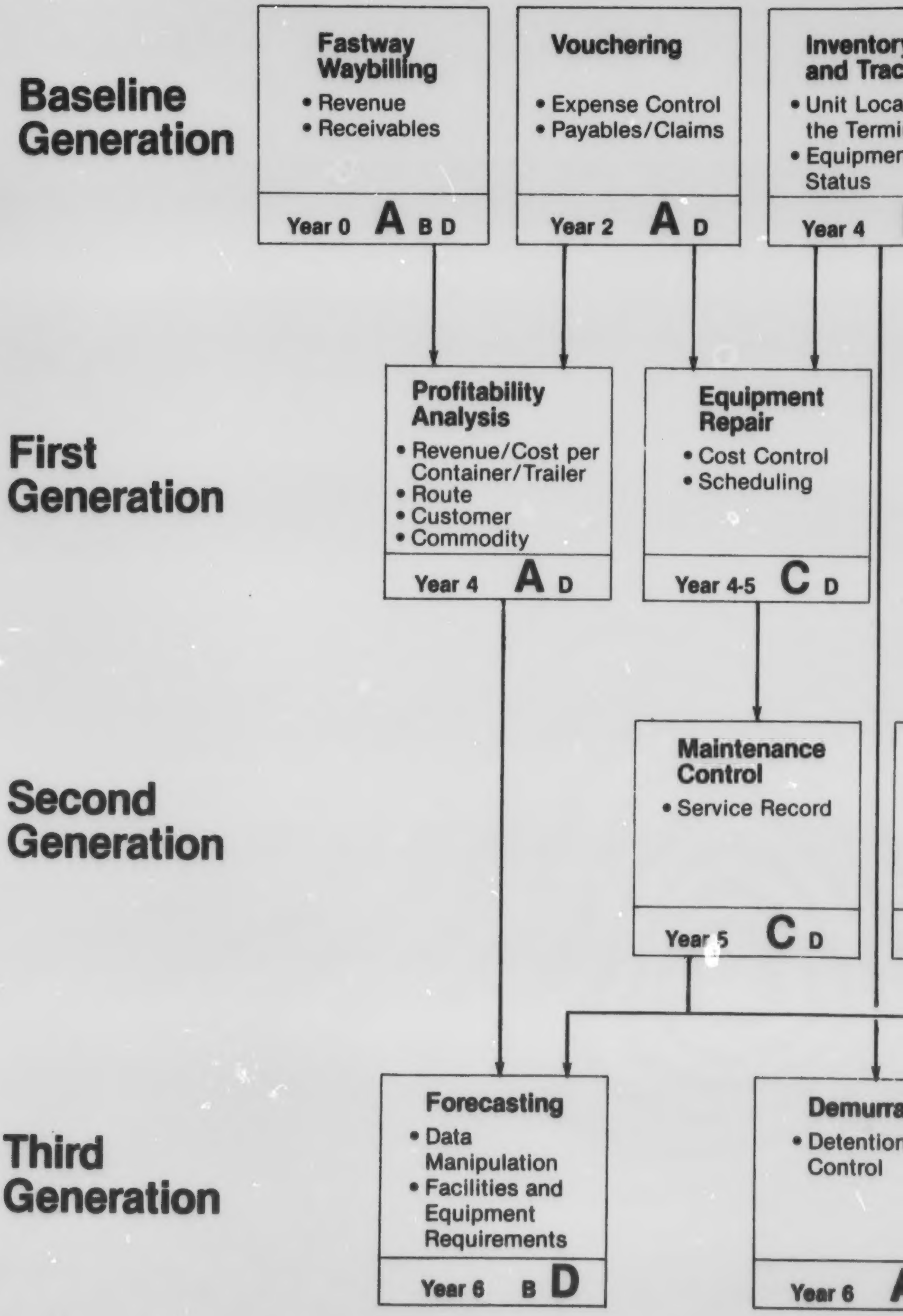
While it is difficult to quantify the benefits to be realized from the implementation of these systems, the following list has been produced to outline the factors which will be used in the cost model in Appendix III

Activity	200,000 units/year	400,000 units/year
a) Savings in unit costs		
P & D Costs	2%	3%
Hostling Costs	1%	2%
b) Savings in operating costs of handling equipment	2%	3%
c) Savings in clerical and administrative costs	Fixed - no increase	15% increase over 200,000 units

The system implementation costs are expected to cost $850,000 as follows:

Advanced Train Notification System	-	$100,000
Inventory Control and Tracing	-	250,000
Truck Dispatch and Scheduling	-	500,000
		$850,000

Since the benefits of the installation of these systems will benefit all of the terminals across the country, only 40 percent or $350,000 of this investment is attributed to Terminal 'X'.


Baseline Generation
First Generation
Second Generation
Third Generation
Fastway Waybilling
• Revenue
• Receivables
Year 0 A B D
Vouchering
• Expense Control
• Payables/Claims
Year 2 A D
Inventor
and Trac
• Unit Loca
the Termi
• Equipmen
Status
Year 4
Profitability Analysis
• Revenue/Cost per Container/Trailer
• Route
• Customer
• Commodity
Year 4 A D
Equipment Repair
• Cost Control
• Scheduling
Year 4-5 C D
Maintenance Control
• Service Record
Year 5 C D
Forecasting
• Data Manipulation
• Facilities and Equipment Requirements
Year 6 B D
Demurra
• Detention
Control
Year 6

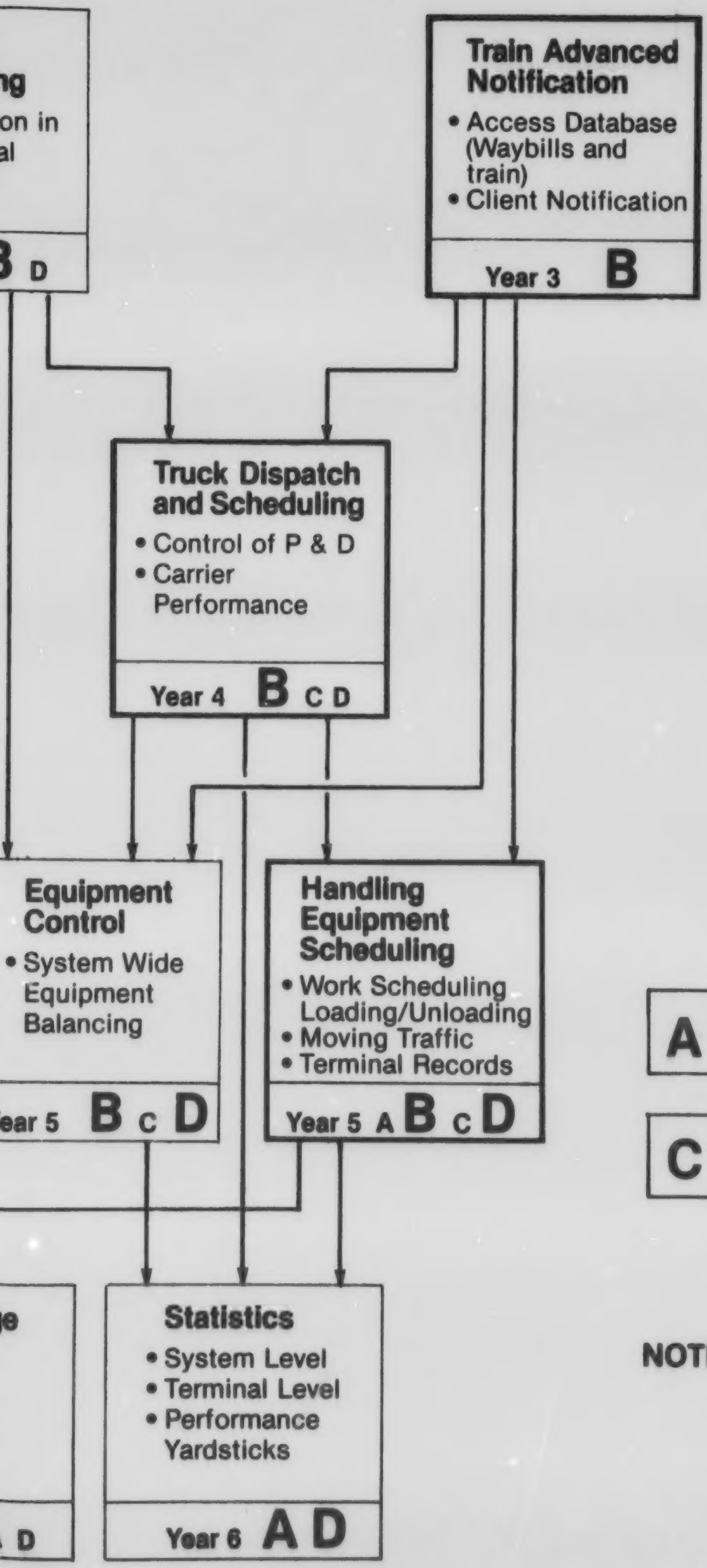

ng
on in
al
B D
Train Advanced Notification
• Access Database (Waybills and train)
• Client Notification
Year 3 B
Truck Dispatch and Scheduling
• Control of P & D
• Carrier Performance
Year 4 B C D
Equipment Control
• System Wide Equipment Balancing
ear 5 B C D
Handling Equipment Scheduling
• Work Scheduling Loading/Unloading
• Moving Traffic
• Terminal Records
Year 5 A B C D
e
D
Statistics
• System Level
• Terminal Level
• Performance Yardsticks
Year 6 A D

Figure 3.8

Intermodal Management Information Systems — Tactical Plan

Legend

A Business Systems	**B** Operations Systems
C Facilities and Equipment	**D** Reporting

NOTE: Bold letters represent functions achieving the major benefit from the installation of the specific phase. Other letters indicate a smaller or ancilliary benefit. The bold outline indicates elements of the Terminal Management System.

For the purpose of determining the equipment requirements for the individual cases studied, the simplifying assumption is made

APPENDIX III

COST MODEL

Table 4.6 Hostling Tractor Handling Factors

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2. TERMINAL CONFIGURATIONS

1. INTRODUCTION

In order to form a structured basis for evaluating the technical findings of this study, the cost analysis of an existing terminal and different expansion options was performed. This cost analysis highlights the financial impact of expanding Terminal 'X' from 100,000 units per year capacity to 400,000 units per year. The main thrust was to determine the capital cost breakdown of the different options and then to determine the annual operating costs. The comparison of the two helped in the determination of the most cost-effective options for expansion.

1.1 Methodology

An existing terminal was used as a basis for determining the data to be analysed. Two approaches were used to complete a workable set of figures. Actual 1981 operating costs were used as well as engineering estimates for capital expenditures involving civil engineering works and equipment purchases. The Cost Model is based upon the following three general assumptions:

- The terminals are assumed to handle an equally split traffic mix of one-third marine containers, one-third Domestic Containers, and one-third trailers. Had the evaluation of the options not considered Domestic Containers, the traffic mix would have been two-thirds trailers and one-third marine containers.
- The capacities of the terminal options are assumed to be:
  - 100,000 units per year for Case A;
  - 200,000 units per year for Cases B1 and B2;
  - 400,000 units per year for Cases C1, C2, C3 and C4.
- The cost evaluation is based on 1981 operating results and the equipment priced at 1981 cost levels.

1.2 General Terminal Configurations

The 'optimum' terminal configuration is determined as much by the space available and the geometric configuration of the property under consideration as it is upon the handling equipment and operating techniques employed. The width of the property is a critical factor in selecting the equipment used and the trackage arrangements installed. For these reasons, it is not possible to select the "perfect" terminal configuration for a given annual throughput.

The design parameters for trailers used in this study are presented in Annex 4.1 and include such details as track centres, trailer parking requirements, handling equipment, space requirements etc. Annex 4.2 presents sketches of 14 typical terminal working area configurations which can be considered for any terminal application being designed using present-day technology.

Annex 4.2.14 presents a summary of these various configurations and a ranking according to working area storage areas (i.e. space efficiency), and hostling needs. This table shows that integral terminals are more space efficient than transfer terminals and the most efficient layouts are those with 2 centre storage aisles. Annex 4.3 presents the same data for various terminal configurations and handling equipment for loaded and empty marine containers. This annex shows that at high density, terminals 060 cranes have a great space advantage for handling loaded marine containers but only a marginal advantage for handling empties.

The cases studied in the following sections are based upon some of the configurations presented in Annex 4.2 and 4.3. Cases using both integral and transfer terminal layouts are presented in order to show the costs of one versus the other for the traffic levels considered. Sprint terminal layouts are not considered in this study because it is felt that they could not operate effectively when handling the 3 intermodal equipment designs (trailers, Domestic Containers, and marine containers).

1.3 Physical Requirements for Conceptual Terminals

A series of "rules-of-thumb" or factors can be developed in order to determine the design requirements for any terminal under consideration. For the purposes of this study, the seasonalities and traffic peaks experienced at the existing terminal are assumed to apply to all other traffic levels for the cases studied. The data presented in Table 2.20 of Appendix I have been used to develop the trackage and storage area factors as follows:

Table 4.1 Trackage and Storage Design Factors

		Trackage @ 1.0 Turns/Day		Storage	
Service	Annual Volume (units)	Required (feet)	Factor (per annual volume unit)	Required	Factor (per annual volume unit)
Trailers	72,528	11,171	0.154 ft.	335 units	0.0046 units
Domestic Containers	66,000	7,006	0.106 ft.		
- loaded				164 units	0.0025 units
- empty				133 units	0.0160 units
- chassis				50 units	0.0170 units
Marine Containers	75,447	6,467	0.086 ft.		
- loaded				1,210 TEU	0.0160 TEU
- empty				1,286 TEU	0.0170 TEU

The figures used for domestic chassis storage requirements have been estimated. There is insufficient data available with which to determine accurate figures based upon historical data because Domestic Containers have only recently been introduced.

Applying the constants developed above to the throughput assumptions for the cases under consideration gives the physical requirements for trackage and storage as follows:

Table 4.2 Storage and Trackage Requirements - All Cases

	Case A	Cases B1, B2	Cases C1 C2, C3, C4
Annual Throughput (units)			
Total	100,000	200,000	400,000
Trailers	33,333	66,667	133,333
Domestic Containers	33,333	66,667	133,333
Marine Containers	33,333	66,667	133,333
Trackage Requirements at 1.0 Turn per Day (lineal feet)			
Trailers	5,133	10,267	20,533
Domestic Containers	3,533	7,067	14,133
Marine Containers	2,867	5,733	11,467
Storage Requirements			
Trailers (units)	153	307	613
Domestic Containers (units)			
- loaded	83	167	333
- empty	67	133	267
- chassis	25	50	100
Marine Containers (TEU)			
- loaded	533	1,067	2,133
- empty	567	1,133	2,267

These requirements are used in subsequent sections of this Appendix.

The space required to store empty trailers in remote off-site locations has been developed from the existing remote on-site storage now in use at Terminal 'X' as follows (see Figure 4.1):

Remote trailer storage - 5.40 acres = 235,224 sq.ft. ÷ 243 trailers
= 968 sq.ft./trailer

This factor has been rounded off to 1,000 square feet per trailer and is used in Section 2 to determine the off-site requirements for the high volume cases.

The basic storage factors required for loaded and empty marine containers are presented in Annex 4.3. These factors must be increased by 15 percent to account for access lanes and are used to determine off-site storage requirements in Section 2. Domestic Container storage requirements are increased by a further 20 percent over those required for a 40-foot marine container to account for the larger dimensions of the Domestic Containers.

1.4 Present Terminal 'X' Land Use

The terminal area is subdivided into 3 major sections as illustrated in Figure 4.1.

The first area is designated as administration and is used for gate entry and exit checks, the weight scale and inspection areas, the office buildings, handling equipment repair and storage areas, reefer and heated trailer and container servicing, etc. It accounts for approximately 5.7 acres at the existing traffic volumes. For the throughput volumes in the B and C cases, at least 6 acres should be provided for administrative functions.

The second area, designated as the remote on-site storage area, is located at the end of the tracks. This section has no tracks and is used exclusively for the storage of loaded and empty trailers coming off the ramps or awaiting loading, for containers that require more than one day's storage, and for the storage of empty containers.

The third area is called the working area. This section includes the trailer ramp-tracks, storage for both trailers and containers, the working areas for the handling equipment, and some of the traffic lanes.

1.5 Equipment Capacity

On peak days, it is assumed that the loading of rail cars will take place during the afternoon and late evening while rail car unloading will occur during the morning. Based upon the information developed in Appendix I, the following table has been prepared to determine the hours worked at the terminal during peak periods.

Table 4.3 Peak Working Hours

Activity	Source Figure	Working Hours From	Working Hours To	Effective Hours (1)	Peak Hours (2)	% Daily Units During Peak Hours
Unloading - trailers	2.9	06:00	11:00	5	3	90%
- domestics	2.10	06:00	11:00	5	3	90%
- marines (2)	2.11	16:40	02:00	6	5	90%
Loading - trailers	2.12	12:00	24:00	10	5	75%
- domestics	2.13	12:00	23:00	9	5	75%
- marines	2.14	14:00	22:00	7	6	90%

(1) excluding lunch breaks and personal time.

(2) marine containers are normally handled during the same morning peak as are trailers and Domestic Containers. The hours in Figure 2.11 are distorted because of the late arrival of the container train.

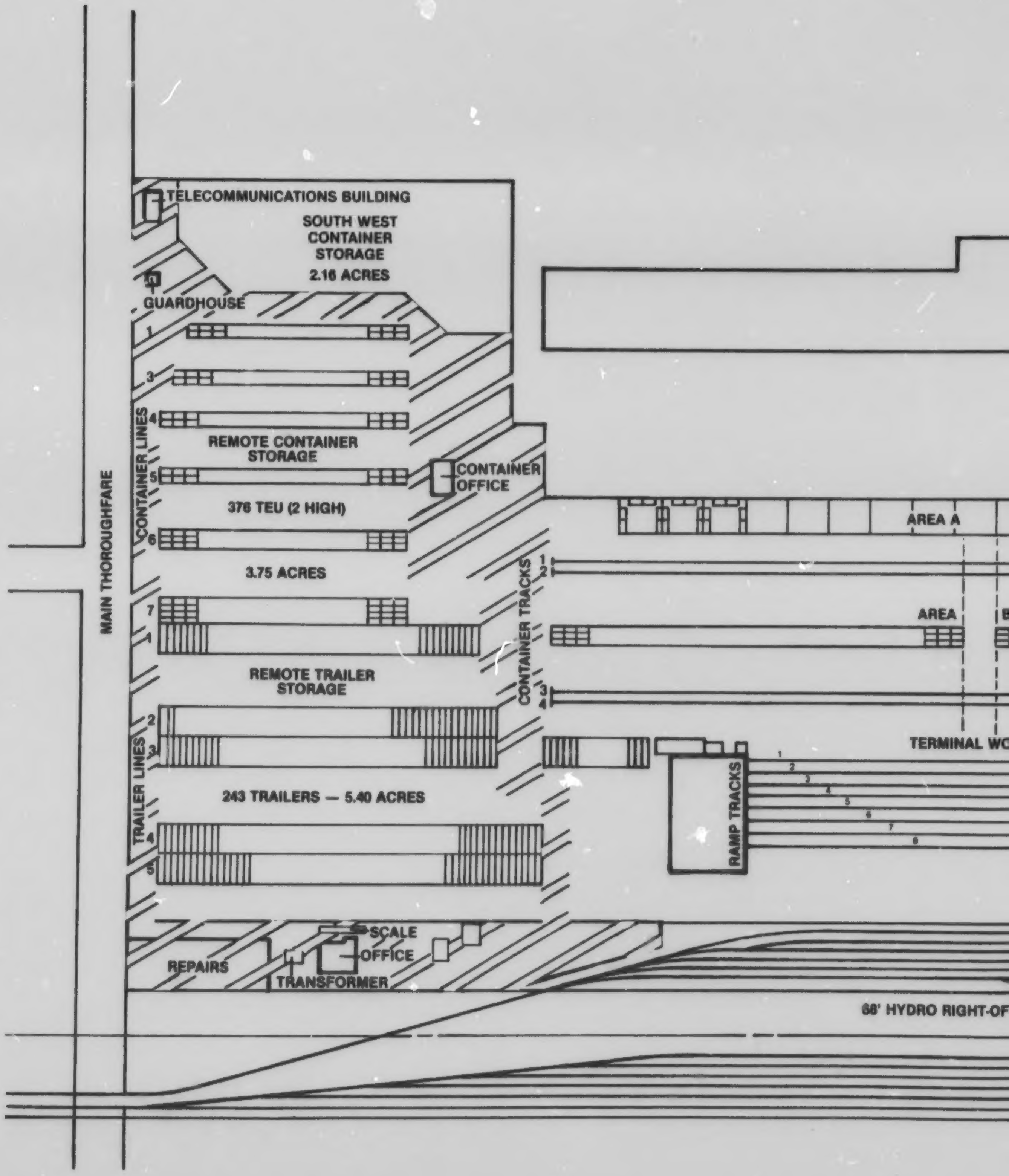
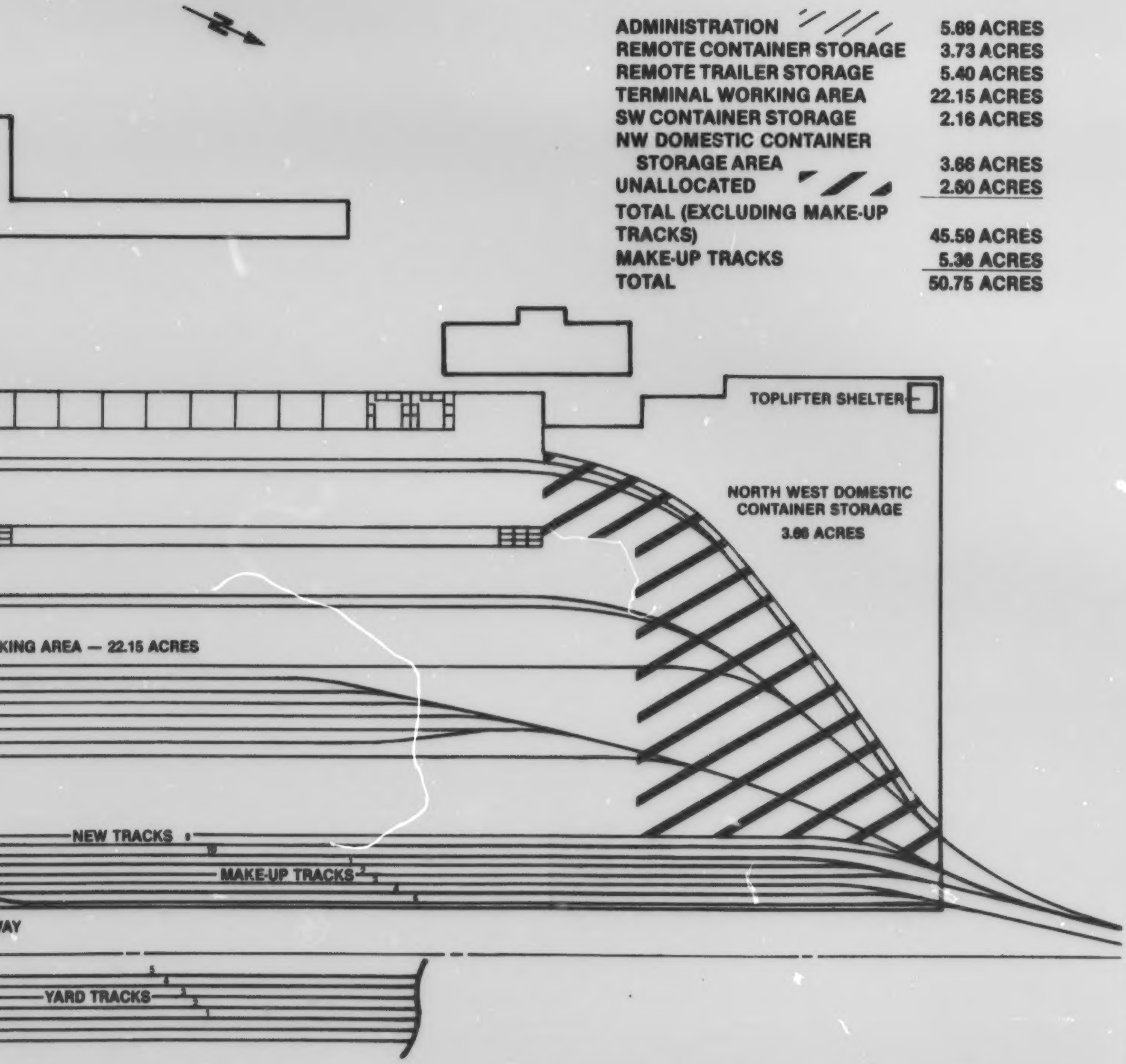

TELECOMMUNICATIONS BUILDING
SOUTH WEST CONTAINER STORAGE
2.16 ACRES
GUARDHOUSE
1
3
4
5
6
7
CONTAINER LINES
REMOTE CONTAINER STORAGE
376 TEU (2 HIGH)
3.75 ACRES
CONTAINER OFFICE
MAIN THOROUGHFARE
AREA A
AREA
1
2
CONTAINER TRACKS
3
4
REMOTE TRAILER STORAGE
1
2
3
4
5
TRAILER LINES
243 TRAILERS — 5.40 ACRES
TERMINAL WO
RAMP TRACKS
1
2
3
4
5
6
7
8
SCALE
OFFICE
REPAIRS
TRANSFORMER
66' HYDRO RIGHT-OF

Figure 4.1
Present Terminal Land Use

ADMINISTRATION	▨	5.69 ACRES
REMOTE CONTAINER STORAGE		3.73 ACRES
REMOTE TRAILER STORAGE		5.40 ACRES
TERMINAL WORKING AREA		22.15 ACRES
SW CONTAINER STORAGE		2.16 ACRES
NW DOMESTIC CONTAINER STORAGE AREA		3.66 ACRES
UNALLOCATED	▨	2.60 ACRES
TOTAL (EXCLUDING MAKE-UP TRACKS)		45.59 ACRES
MAKE-UP TRACKS		5.36 ACRES
TOTAL		50.75 ACRES


TOPLIFTER SHELTER
NORTH WEST DOMESTIC CONTAINER STORAGE
3.66 ACRES
KING AREA — 22.15 ACRES
NEW TRACKS
9
10
MAKE-UP TRACKS
1
2
3
4
5
AY
YARD TRACKS
5
4
3
2
1

For the purpose of determining the equipment requirements for the individual cases studied, the simplifying assumption is made that the following hourly and peak period handling rates presented in Table 4.4 can be attained on a sustained basis based upon the peak hours developed in Table 4.3.

Because the times allowed for unloading are much shorter than those allowed for loading, the unloading requirements govern the handling equipment required. When calculating the equipment requirements in Section 2, an additional 20 percent has been added to the numbers generated by using the above figures in order to allow for routine maintenance.

1.6 Daily Handling Requirements

These requirements are based upon the normal peak day (a typical Friday) as discussed in Appendix I. Table 2.8 provides a forecast of the handlings required for the days of the week in 1984 for the annual volumes expected. These figures are used to develop the peak day (Friday) requirements as a function of annual throughput as follows:

Table 4.5 Peak Daily Handling Requirement Factors

Activity	Units Handled	Annual Volume	Factor Per 10,000 Annual Units
Loading - trailers	194	72,528	2.675
- domestics	147	66,000	2.227
- marines	132	75,447	1.750
Unloading - trailers	137	72,528	1.889
- domestics	99	66,000	1.500
- marines	200	75,447	2.651

1.7 Hostling Tractor Requirements

Because the handling equipment requirements are based upon the unloading volumes rather than the loading volumes (see Section 1.5), so too will the requirements for hostling tractors be based upon the number of units to be handled (using the factors presented in Table 4.5). The handling times and average hourly handlings presented in Table 4.6 are based upon the 3-minute average for the circus unloading of trailers determined in Appendix 1.

Table 4.4 Handling Equipment Capacities During Peak Working Periods

Activity	Cycles Per Hour		Handlings Per Hour		Peak Hours		Handlings During Peak	
	Unloading Railcars	Loading Railcars	Unloading Railcars	Loading Railcars	Unloading Railcars	Loading Railcars	Unloading Railcars	Loading Railcars
Piggypackers								
- trailers	24	24	24	24	3	5	72	120
- domestics	20	18	15 (1)	16.2(3)	3	5	45	81
- marines	20	18	10 (2)	14.4(4)	5	6	50	86
Toplifters								
- domestics	22	20	16.5(1)	18 (3)	3	5	51	90
- marines	22	20	11 (2)	16 (4)	5	6	55	96
020, 030 Cranes (transfer operations at trackside only)								
- trailers	24	24	24	24	3	5	72	120
- domestics	20	18	20 (e)	18 (e)	3	5	60	90
- marines	20	18	20 (e)	18 (e)	5	6	100	108
060 Cranes (with marine containers being stored under crane span)								
- marines (loads)	18 (a)	16 (c)	9 (5)	12 (7)	5	6	45	72
- marines (empties)	18 (b)	16 (d)	13.5(6)	12 (8)	5	6	68	72
- average handlings *			9.6	12	5	6	48	72

(*) assuming 86:14 loaded: empty ratio for inbound and 73:27 for outbound (See Table 4.21)

(1) Domestic handlings are reduced by 25 percent to account for placing some containers into storage and for selectively retrieving some containers for delivery.

(2) Marine containers are reduced by 50 percent as in (5).

(3) Domestic handlings reduced by 10 percent to account for empties being retrieved from stockpiles.

(4) Marine handlings reduced by 20 percent to account for empties being retrieved from stockpiles.

(a) Loads handled from rail car to 2-3-3-2 stockpile with non-selective placement into the stockpile from railcar and subsequent selective retrieval for delivery to consignee.

(5) Marine handlings reduced by 50 percent to account for the fact that some containers must be retrieved selectively from the stockpile for delivery during the morning unloading periods. This reduction would also cover the reloading of outbound loads or empties brought into the terminal during this period.

(b) Empties handled from railcar to 4-4-4-4 stockpile with non-selective placement into the stockpile and non-selective retrieval for delivery to shipper.

(6) Marine handlings reduced by 25 percent to account for the fact that some empties must be retrieved non-selectively for delivery during the morning unloading periods. This reduction would also cover the reloading of outbound loads or empties brought into the terminal during this period.

(c) Loads handled directly from chassis account for approximately 70 of the outbound loads. The remaining 30 percent must be handled into the stockpile on a non-selective basis and retrieved on a selective basis.

(7) Marine handlings reduced by 25 percent as in (1).

(d) Empties are handled directly into the stockpile on a non-selective basis and retrieved on the same basis.

(8) Marine handlings reduced by 25 percent as in (2).

(e) No reductions are required to determine handlings per hour because containers without chassis will be brought from (or placed into) stockpiles by toplifters or piggypackers.

Table 4.6 Hostling Tractor Handling Factors

Activity	Average Minutes		Handlings Per Hour	
	To Working Area	To Remote On-site	To Working Area	To Remote On-site
Trailers circus loaded or unloaded	3.0	3.0	20.0	20.0
Trailers loaded or unloaded by packers	2.0	3.0	30.0	20.0
Containers loaded by packers, lifters, or cranes	3.75	5.25	16.0	11.4
Containers unloaded by packers, lifters, or cranes	3.0	4.5	20.0	13.0

The longer times for containers are due to the fact that the hostling tractors must queue with empty chassis and wait for each container to be handled by the piggypacker or toplifter. These tractors' handling times are, therefore, controlled by the handling cycles of the lifting equipment. In Section 2, the number of tractors required will be pro-rated against the storage provided in the working area versus that in the remote on-site area.

An adjustment to the requirements determined above must be made in order to reflect the fact that there presently is a significant transfer of empty containers to a remote off-site location. This operation is referred as shuttling in this study. These adjustments will be made in Section 3.

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2. TERMINAL CONFIGURATIONS

The options studied for the expansion of Terminal 'X' from a 100,000-unit per year handling capacity to a 400,000-unit capacity are designated as Cases A, B1, B2, C1, C2, C3 and C4. Case A is based upon the existing 50-acre terminal using conventional handling technology and storage within the yard. Cases B1 and B2 show how the introduction of piggypackers combined with the removal of the existing piggyback ramps allows the terminal throughout to increase to 200,000 units per year without having to use a remote off-site location for containers. These cases should be compared to the present configuration of Terminal 'X' which uses conventional ramps and requires an off-site storage area at only 150,000 units per year. Cases C1 and C2 both involve the increase of handling capacity to 400,000 units per year within the same land area as Cases B1 and B2 with additional storage being provided at an off-site location. These 2 cases show how the capacity of the terminal can be pushed to the limit. Cases C3 and C4 involve the construction of a new terminal on a new site with the attendant savings in shuttling and switching.

2.1 Case A

The terminal to be expanded is based on the stub-track concept using ramps to handle trailers and toplifters to handle containers. The rail equipment (container and trailer flat cars) is segregated at the marshalling yards and shuttled into the terminal. Access to the terminal is through a single entry lead track which serves for both the entry and exit of railway line-haul equipment. The flat cars with trailers are placed on the ramp tracks. Hostlers then drive up the ramps and pull the trailers off the flat cars into the storage area in sequence (first in, last out). Containers on flat cars are switched into the terminal to the container tracks using the same lead track where toplifters remove them from the flat cars and stack them for storage or place them on chassis for delivery. All storage of trailers and containers is provided for on-site thus eliminating the need and cost of shuttling. Loaded containers are stacked 2 X 2 while empty containers are block stacked only 2 high because there is ample space available at the existing site. Figure 4.2 shows the layout for Case A.

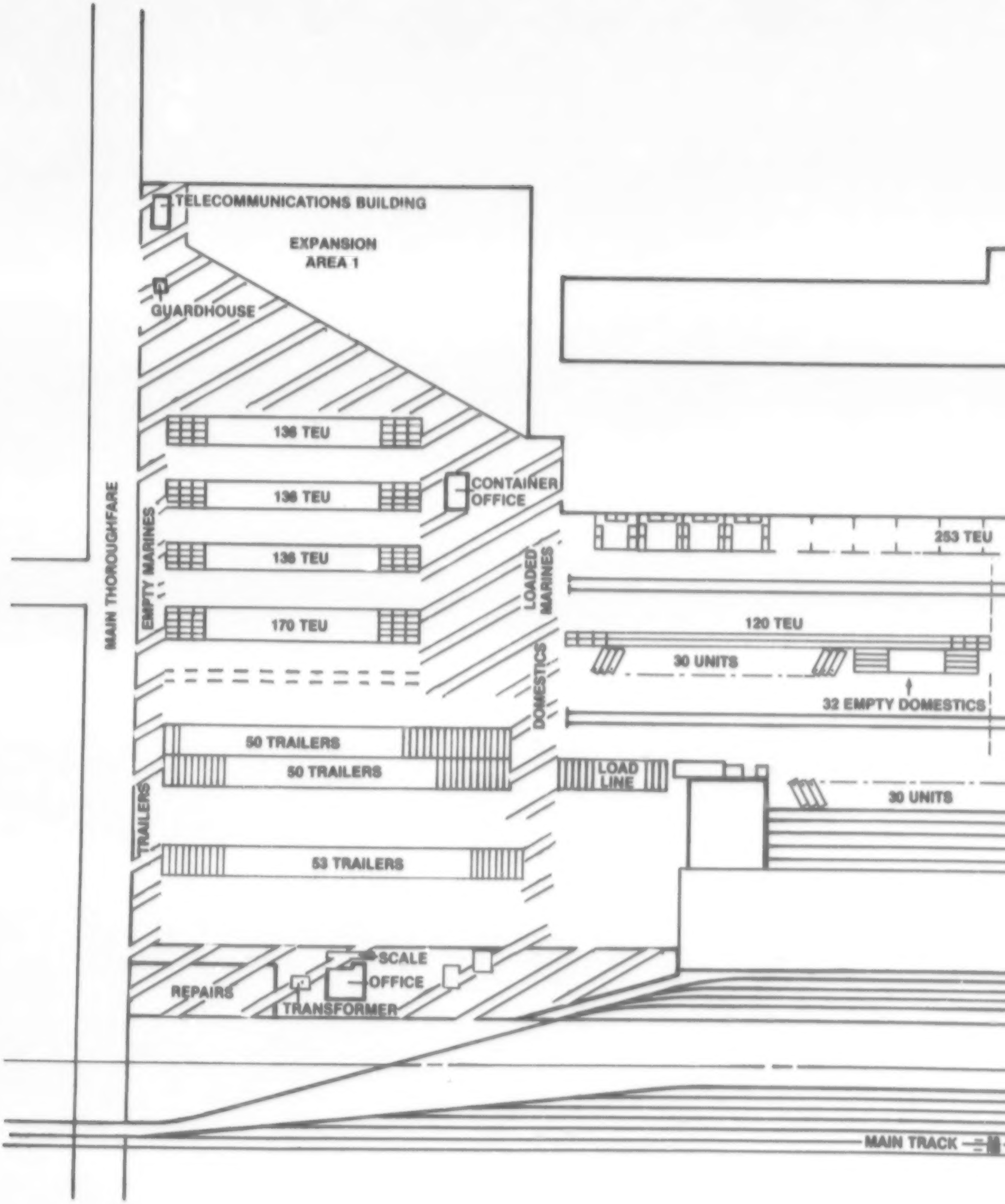
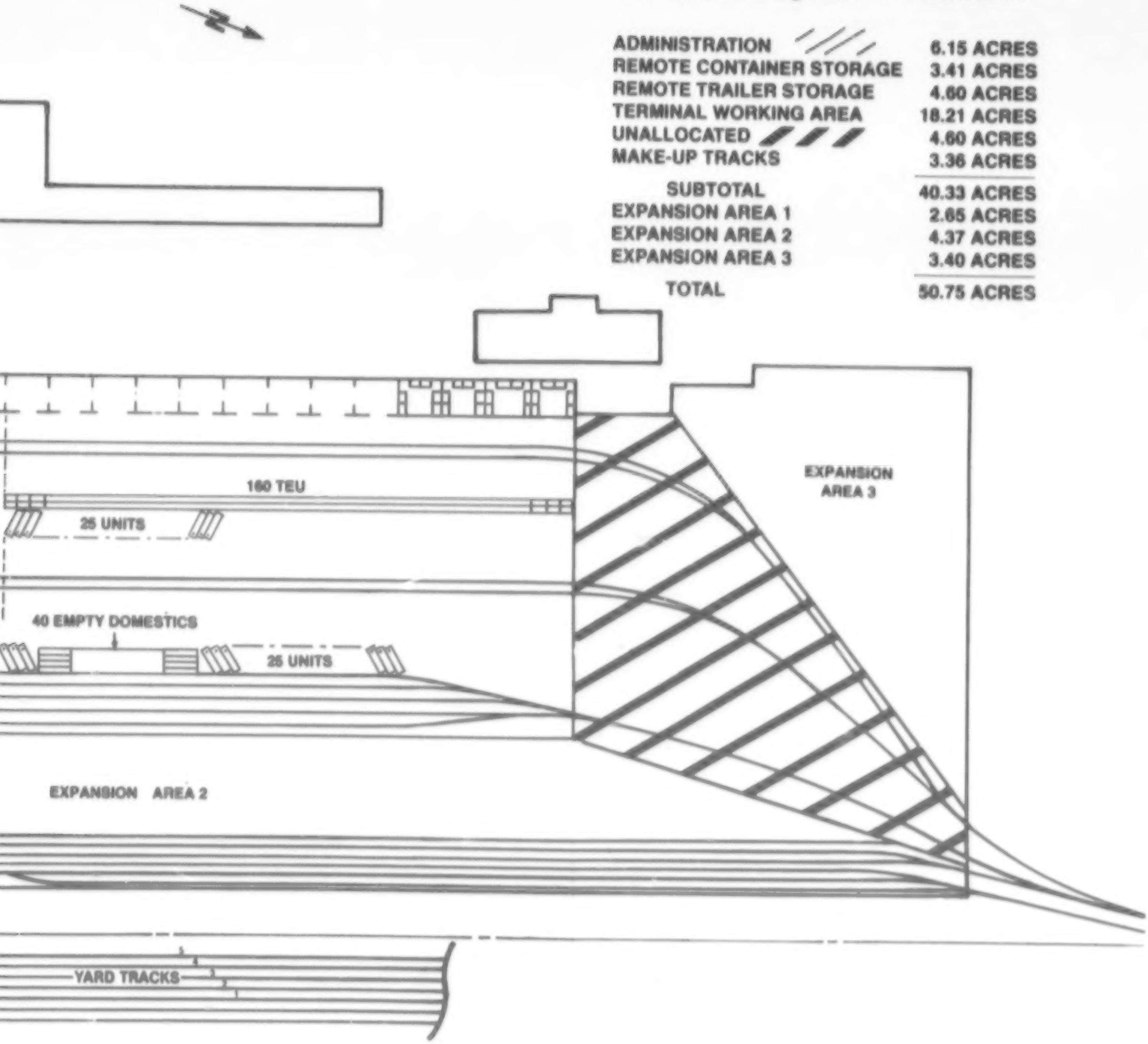

TELECOMMUNICATIONS BUILDING
EXPANSION AREA 1
GUARDHOUSE
136 TEU
136 TEU
136 TEU
170 TEU
CONTAINER OFFICE
MAIN THOROUGHFARE
EMPTY MARINES
LOADED MARINES
253 TEU
120 TEU
30 UNITS
DOMESTICS
32 EMPTY DOMESTICS
50 TRAILERS
50 TRAILERS
LOAD LINE
30 UNITS
TRAILERS
53 TRAILERS
SCALE
OFFICE
REPAIRS
TRANSFORMER
MAIN TRACK

Figure 4.2
Terminal Layout — Case A


N
160 TEU
25 UNITS
40 EMPTY DOMESTICS
25 UNITS
EXPANSION AREA 3
EXPANSION AREA 2
YARD TRACKS

ADMINISTRATION ▨	6.15 ACRES
REMOTE CONTAINER STORAGE	3.41 ACRES
REMOTE TRAILER STORAGE	4.60 ACRES
TERMINAL WORKING AREA	18.21 ACRES
UNALLOCATED ▨	4.60 ACRES
MAKE-UP TRACKS	3.36 ACRES
SUBTOTAL	40.33 ACRES
EXPANSION AREA 1	2.65 ACRES
EXPANSION AREA 2	4.37 ACRES
EXPANSION AREA 3	3.40 ACRES
TOTAL	50.75 ACRES

Using the criteria developed in the previous section, the following requirements have been determined for trackage and storage, assuming one turnover per day for the terminal tracks:

Table 4.7 Case A Track and Storage Requirements versus Availability

Service	Track			Storage			
	Required (feet)	Available (feet)	Turns Per Day	Required	Available		
					Working Area	Remote On-site	Total
Marine Containers	2,867	3,100	0.9				
- loaded (TEU)				533	533	-	533
- empty (TEU)				567	-	578	578
Domestic Containers	3,533	3,100	1.1				
- loaded (units)				83	85	-	85
- empty (units)				67	72	-	72
- chassis (units)				25	25	-	25
Trailers	5,133	5,000	1.0				
- all (units)				153	-	153	153
Total Track	11,533	11,200	1.0				

At 100,000 units per year, the existing facilities are more than adequate to handle the traffic without requiring the use of the remote off-site storage area. The remote on-site area will probably be used for the storage of trailers since it is easier to hostle them off the ramp and into this area than to turn around and drive along the ramp tracks.

The handling equipment requirements for this case are determined as follows:

Table 4.8 Basic Handling Equipment Requirements - Case A

Activity	Annual Volume (units)	Handling Factor (per 10,000 units)	Peak Day Units	Peak Period Units (1)	Peak Period Handlings (2)	Machines Required
Unloading						
- trailers	33,333	1.889	63	57	-	tractors only
- domestics	33,333	1.500	50	45	51	0.9 toplifters
- marines	33,333	2.651	88	79	55	1.4 toplifters
Loading						
- trailers	33,333	2.675	89	67	-	tractors only
- domestics	33,333	2.227	74	56	90	0.6 toplifters
- marines	33,333	1.750	58	52	96	0.5 toplifters

(1) applying the percentages presented in Table 4.3
(2) see Table 4.4

In addition to these basic requirements, the following additional equipment will be required:

- One additional toplifter will be required to handle the empty marine containers in the remote on-site storage area. Although this unit could be a light capacity unit, a heavy duty unit is recommended in order to preserve a commonality of equipment. This unit will operate one shift per day.

When an additional 20 percent for maintenance is added to the above figures, 3 toplifters are required for the peak loading period and 4 toplifters for the peak unloading period. Seven machine operators are required.

The hostling tractor requirements are based upon the factors developed in Tables 4.3, 4.6, 4.7 and 4.8 are as follows:

Table 4.9 Hostling Tractors Required - Case A

Activity	Peak	Peak	Working Area		Remote Area		Weighted	Tractors
	Period Units	Hour Units	Handling Rate	Unit Storage	Handling Rate	Unit Storage	Average Rate	Required
Unloading								
-trailers	57	19.0	-	20.0	153	20.0	20.0	0.95
-domestics	45	15.0	175	20.0	-	13.0	20.0	0.75
								1.70
Loading								
-trailers	67	13.4	-	20.0	153	20.	20.0	0.67
-domestics	56	11.2	175	16.0	-	11.4	16.0	0.70
								1.37

An additional 25 percent is added to this figure in order to account for dispatching delays. The number of tractors required is, therefore, 2 tractors for the loading period and 3 tractors for the peak unloading period. Five tractor driver are required.

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2.2 Case B1

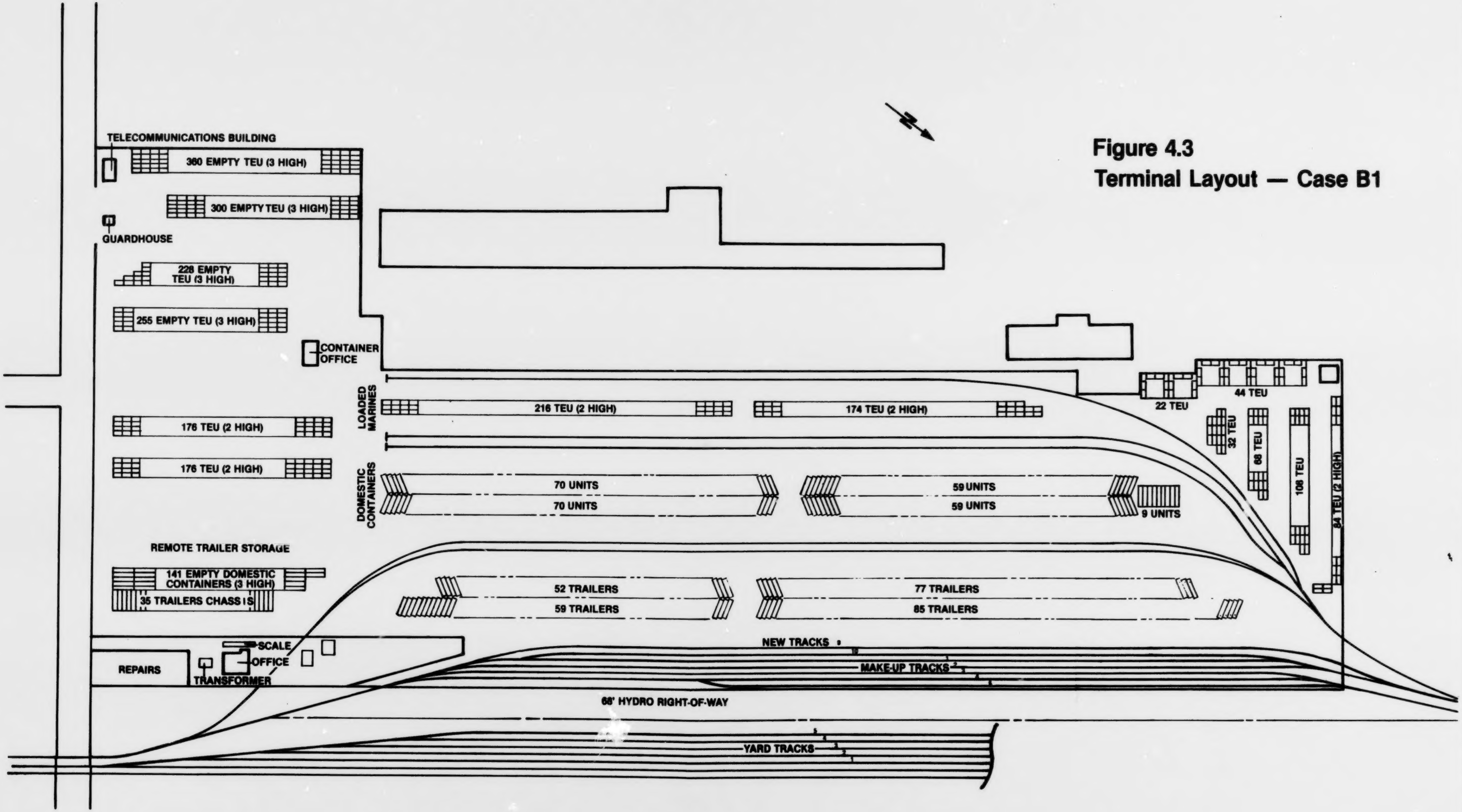
This case assumes that the expansion of Terminal 'X' to handle an annual throughput of 200,000 units per year is made by converting it to an integral terminal with no off-site storage. This conversion is accomplished by removing the piggyback ramp and replacing the circus loading of trailers with side transferring using piggypackers. In this case empty containers are stored 3 high in order to increase the density of the block storage piles. The length of tracks in the yard is reduced dramatically because of the removal of the ramp tracks which allows the yard engine to turn the tracks more frequently. The greatest amount of ground storage is located in the working area between the tracks. One possible layout is presented in Figure 4.3.

Using the physical requirements for the 200,000 unit throughput developed in Table 4.2, the following comparison of the requirements versus availability is made.

Table 4.10 Case B1 Track and Storage Requirements versus Availability

	Track			Storage			
					Available		
Service	Required (feet)	Available (feet)	Turns Per Day	Required	Working Area	Remote On-site	Total
Marine Containers	5,733	3,790	1.5				
- loaded (TEU)				1,067	390	710	1,100
- empty (TEU)				1,133	-	1,143	1,143
Domestic Containers	7,067	3,960	1.8				
- loaded (units)				167	267	-	267
- empty (units)				133	-	141	141
- chassis (units)				50	-	35	35
Trailers	10,267	3,840	2.7				
- all (units)				307	273	-	273
Total Track	23,067	11,590	2.0				
Total Trailers, Loaded Domestic Containers and Chassis				524	540	35	575
External Tracks							
- make-up	9,950						
- yard	14,250						
- dump	3,450						
	27,650						

Figure 4.3
Terminal Layout — Case B1


N
TELECOMMUNICATIONS BUILDING
360 EMPTY TEU (3 HIGH)
300 EMPTY TEU (3 HIGH)
GUARDHOUSE
228 EMPTY TEU (3 HIGH)
255 EMPTY TEU (3 HIGH)
CONTAINER OFFICE
LOADED MARINES
216 TEU (2 HIGH)
174 TEU (2 HIGH)
22 TEU
44 TEU
32 TEU
68 TEU
108 TEU
84 TEU (2 HIGH)
176 TEU (2 HIGH)
176 TEU (2 HIGH)
DOMESTIC CONTAINERS
70 UNITS
70 UNITS
59 UNITS
59 UNITS
9 UNITS
REMOTE TRAILER STORAGE
141 EMPTY DOMESTIC CONTAINERS (3 HIGH)
35 TRAILERS CHASSIS
52 TRAILERS
59 TRAILERS
77 TRAILERS
85 TRAILERS
SCALE
OFFICE
REPAIRS
TRANSFORMER
NEW TRACKS
MAKE-UP TRACKS
68' HYDRO RIGHT-OF-WAY
YARD TRACKS

From the previous table, several important features become apparent. The total ground storage requirements can be handled easily, although some of the trailers and Domestic Container chassis may have to be stored in the Domestic Container working area during peak hours. The track utilization must also increase dramatically from Case A. This increase should present the yard engine crews little problem because the number of tracks to be switched has been reduced from 13 (present Terminal 'X') to 6 and there is sufficient external storage with which to hold the entire complement of cars on the peak day (27,932 feet). Additionally, the provision of an access from the south to Trailer 1 and 2 and to Container 1 will help to reduce switching delays when the road engines are switching the yard tracks. The fact that a larger part of the ground storage is located in the working area means that hostling costs should be reduced. Also, since there is no requirement for remote off-site storage, there will be no shuttling costs.

The handling equipment requirements have been determined using the factors developed in Tables 4.3 and 4.4, and 4.5 as follows:

Table 4.11 Basic Handling Equipment Requirements - Cases B1 and B2

Activity	Annual Volume (units)	Handling Factor (per 10,000 units)	Peak Day Units	Units Per Machine	Machines Required
Unloading					
- trailers	66,667	1.889	126	72	1.8 packers
- domestics	66,667	1.500	100	51	2.0 toplifters
- marines	66,667	2.651	177	55	3.2 toplifters
Loading					
- trailers	66,667	2.675	178	120	1.5 packers
- domestics	66,667	2.227	148	90	1.6 toplifters
- marines	66,667	1.750	117	96	1.2 toplifters

(1) applying the percentages presented in Table 4.3
(2) see Table 4.4

In addition to the above basic requirements for trackside handling, the following auxiliary machines are required;

- one toplifter for handling loaded marine containers in the remote area along the north property line (this unit can assist in unloading the railcars when not busy);
- one toplifter for handling the empty marine storage area;
- one toplifter to handle the Domestic Container storage area and the loaded marine storage area along the south property line.

The total handling machinery requirements including 20 percent for maintenance for this case are, therefore, 3 piggypackers and 7 toplifters for the peak loading period. One of the 5 toplifters can be a light capacity model capable of handling empty containers only. For the peak unloading periods, 3 piggypackers, 9 toplifters, and 1 light toplifter are required. Nineteen machine operators are required.

The hostling tractor requirements are based upon the factors developed in Tables 4.3, 4.5, 4.9. and 4.10 as follows:

Table 4.12 Hostling Tractors Required - Case B1

Activity	Peak Period Units	Peak Hour Units	Working Area Handling Rate	Working Area Unit Storage	Remote Area Handling Rate	Remote Area Unit Storage	Weighted Average Rate	Tractors Required
Unloading								
- trailers	113	37.7	30.0	282	20.0	25	29.2	1.29
- domestics	90	30.0	20.0	305	11.4	45	19.1	1.57
								2.86
Loading								
- trailers	134	26.8	30.0	282	20.0	25	29.2	0.92
- domestics	111	22.2	16.0	305	11.4	45	15.4	1.44
								2.36

An additional 25 percent is added to these figures in order to account for delays. The number of tractors required is, therefore, 4 tractors for the unloading periods and 3 tractors for the loading periods. Seven tractor drivers are required.

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2.3 Case B2

This case is also designed to show how Terminal 'X' can be expanded to handle 200,000 units per year by converting part of it to a transfer terminal with very little ground storage being provided in the working area. The trailer ramps are again replaced with long tracks being handled with piggypackers, however, more remote on-site storage is required. Figure 4.4 illustrates the configuration examined in this case.

The track and storage requirements compared to what can be provided is as follows:

Table 4.13 Case B2 Track and Storage Requirements versus Availability

	Track			Storage			
Service	Required (feet)	Available (feet)	Turns Per Day	Required	Available		
					Working Area	Remote On-site	Total
Marine Containers	5,733	3,200	1.8				
- loaded (TEU)				1,067	533	574	1,107
- empty (TEU)				1,133		1,143	1,143
Domestic Containers	7,067	7,160	1.0				
- loaded (units)				167	233		233
- empty (units)				133		150	150
- chassis (units)				50		35	35
Trailers	10,267	5,450	1.9				
- all (units)				307	122	138	260
Total Track	23,067	15,810	1.5				
Total Trailers, Loaded Domestic Containers and Chassis				524	355	173	528
External Tracks:							
- make-up	9,950						
- yard	14,250						
- dump	3,450						
	27,650						

The basic advantage that Case B1 has over Case B2 is that there is more storage area available in the working area in Case B1 which reduces the amount of on-site hostling required. In order to gain this advantage, however, the tracks must be turned more often in Case B1 because of the reduced trackage on-site.

The handling equipment requirements are the same in Case B2 as in B1 (see Table 4.11).

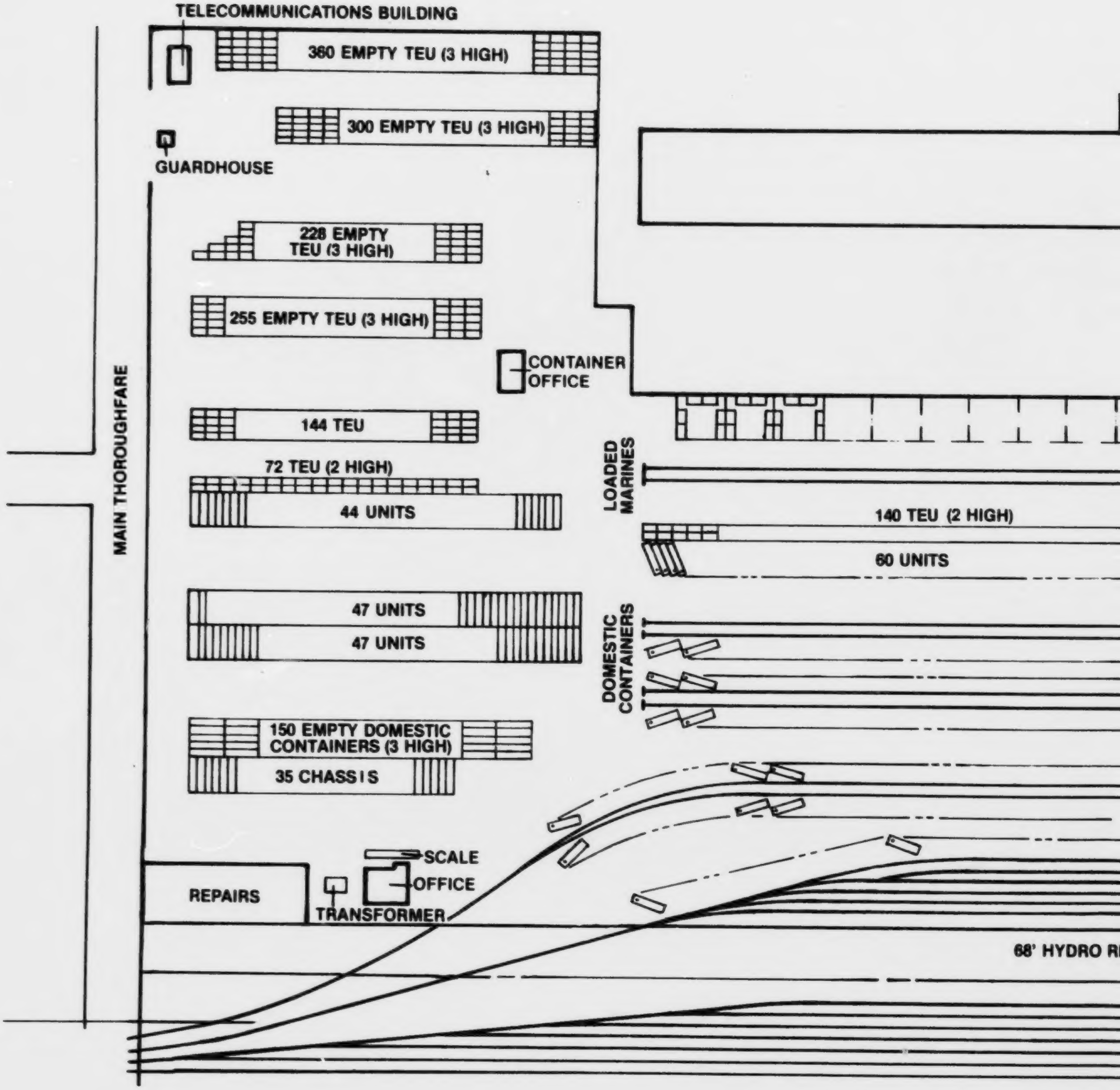
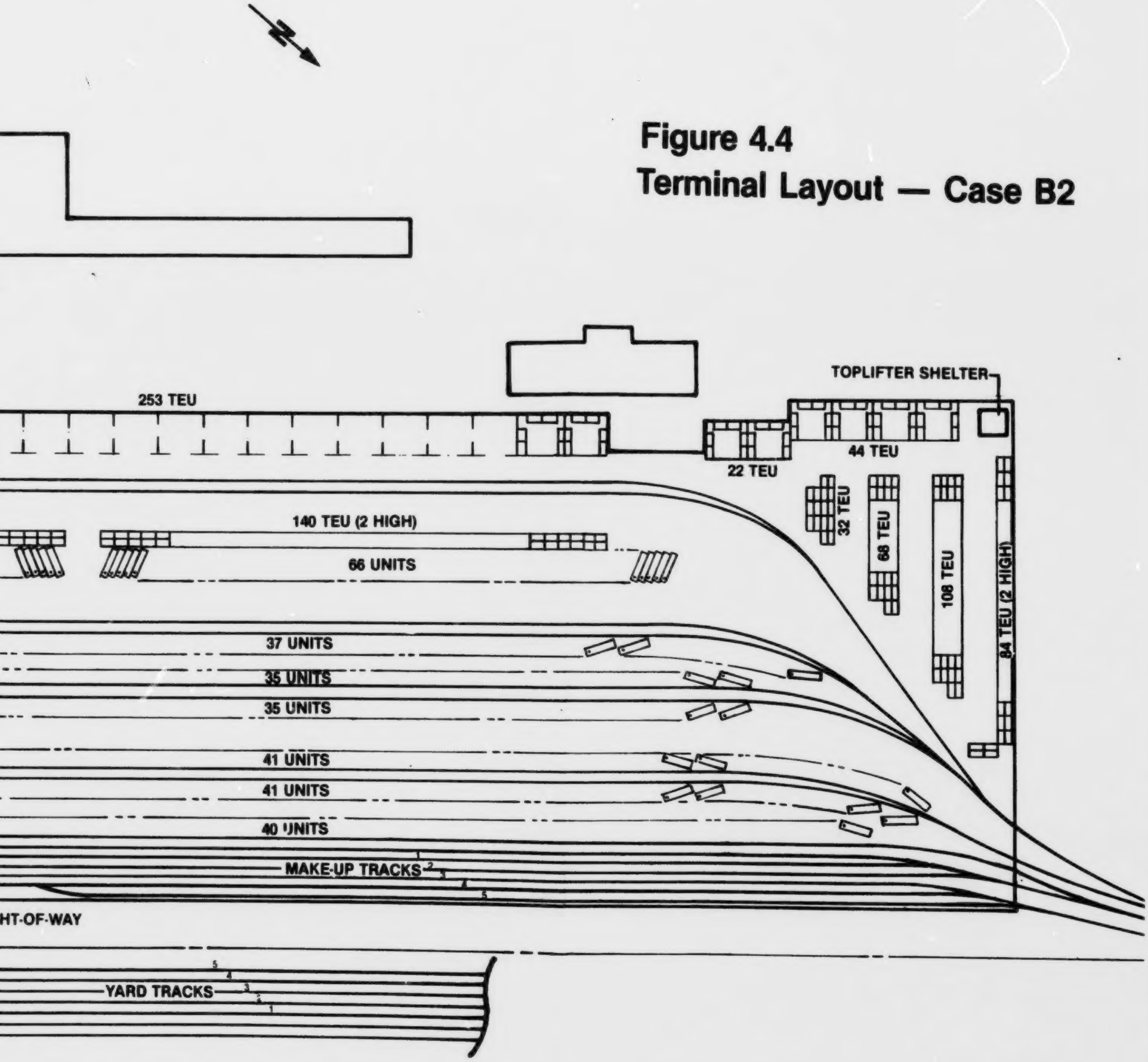

TELECOMMUNICATIONS BUILDING
360 EMPTY TEU (3 HIGH)
300 EMPTY TEU (3 HIGH)
GUARDHOUSE
228 EMPTY TEU (3 HIGH)
255 EMPTY TEU (3 HIGH)
CONTAINER OFFICE
144 TEU
72 TEU (2 HIGH)
44 UNITS
MAIN THOROUGHFARE
LOADED MARINES
140 TEU (2 HIGH)
60 UNITS
47 UNITS
47 UNITS
DOMESTIC CONTAINERS
150 EMPTY DOMESTIC CONTAINERS (3 HIGH)
35 CHASSIS
SCALE
OFFICE
REPAIRS
TRANSFORMER
68' HYDRO R

Figure 4.4
Terminal Layout — Case B2


N
TOPLIFTER SHELTER
253 TEU
22 TEU
44 TEU
32 TEU
68 TEU
108 TEU
84 TEU (2 HIGH)
140 TEU (2 HIGH)
66 UNITS
37 UNITS
35 UNITS
35 UNITS
41 UNITS
41 UNITS
40 UNITS
MAKE-UP TRACKS
1
2
3
4
5
HT-OF-WAY
YARD TRACKS
5
4
3
2
1

The requirements for hostling tractors is determined below, based upon the unloading requirements as discussed previously.

Table 4.14 Hostling Tractors Required - Case B2

Activity	Peak	Peak	Working Area		Remote Area		Weighted	Tractors
	Day Units	Hour Units	Handling Rate	Unit Storage	Handling Rate	Unit Storage	Average Rate	Required
Unloading								
- trailers	113	37.7	30.0	122	20.0	185	24.0	1.57
- domestics	90	30.0	20.0	233	13.0	117	17.7	1.69
								3.26
Loading								
- trailers	134	26.8	30.0	122	20.0	185	24.0	1.12
- domestics	111	22.2	16.0	233	11.4	117	14.5	1.53
								2.65

Adding the 25 percent for dispatching delays and an additional 10 percent for repairs brings the total requirement for hostling tractors to 4 tractors for the peak unloading period and 4 tractors for the loading period. Eight tractor drivers are required.

2.4 Conclusions Regarding Cases B1 and B2

Both of these cases will require an improved level of up-to-date location information so that the loading operations during the evening and nighttime hours can be destination segregated, i.e. long blocks of single destination traffic must be loaded at one time because the yard engine will not have enough time to marshall sets of cars in the make-up and yard tracks. Appendix II discusses these information systems requirements in greater detail.

It is interesting to note that the advent of piggypackers for the handling of trailers has created the ability to design yard layouts which are much more space efficient. Regardless of the design concepts instituted (transfer terminal or integral terminal), the removal of the traditional circus loading tracks and ramps and the subsequent increase in track turnaround allows more on-site storage. In the case of Terminal 'X', the traditional layout requires an off-site remote storage area for the empty marine containers at an annual throughput of 150,000 units. By converting to a piggypacker operation, the same terminal can handle 200,000 units per year without requiring an off-site remote storage area.

2.5 Case C1

This case shows the logical expansion of the layout designated as Case B1 from 200,000 units per year to 400,000 units per year. This expansion takes place on the existing site by increasing the density of the marine container handling facilities and by moving the storage of empty marine and Domestic Containers to a remote off-site location. The increase in density of the marine container handling facilities is accomplished by replacing the toplifters with long span OGO cranes. The terminal layout for Case C1 is presented in Figure 4.5. Although not shown in Figure 4.5, the layout assumes that the 100 Domestic Container chassis will be stored between the pole lines on the hydro easement. This arrangement is now in effect at 'Terminal 'X' for empty trailers.

The increase in terminal throughput would be accomplished without adding further to the number of tracks. This further increase in track turnaround would be made possible by constructing a new switching lead to connect the south end of the tracks in the working area with the make-up tracks, yard tracks and the main tracks. With the volume of traffic increasing to the same number of destinations, more solid intermodal trains will be operated. The provision of a run-through capability at the terminal will allow some of the road units to assist the yard engine at the other end of the terminal tracks.

Because of the large number of switching movements crossing the main thoroughfare, this case cannot be implemented until a grade separation is built. The economic analysis presented in Section 3 takes the railway portion of this investment into account. The make-up and yard tracks must also be extended to provide more holding capacity for cars held off-site.

The amount of trackage external to the terminal (i.e. make-up, yard tracks and the auxiliary storage yard becomes insufficient as the throughput approaches 400,000 units per year. Although the yard and make-up tracks can be extended slightly (see figure 4.5) and the holding capacity of the auxiliary storage yard can be doubled, there is still a slight shortage of holding capacity of some 350 feet. The assumption is made in this study that some empty cars can be held for short periods of time during peak days on the main tracks or service tracks to the north of the auxiliary storage yard.

The area required for remote off-site storage, assuming that toplifters are used to block stack in 4 X 4 piles, is determined from the factors developed in Section 1.3 and Annex 4.3.5 as follows:

Empty marine containers
2,267 TEU X 82 sq.ft./TEU X 1.15 = 213,778 sq.ft. = 4.91 acres

Empty Domestic Containers
267 units X 196.8 sq.ft./unit X 1.15 = 60,427 sq.ft. = 1.39 acres

6.30 acres

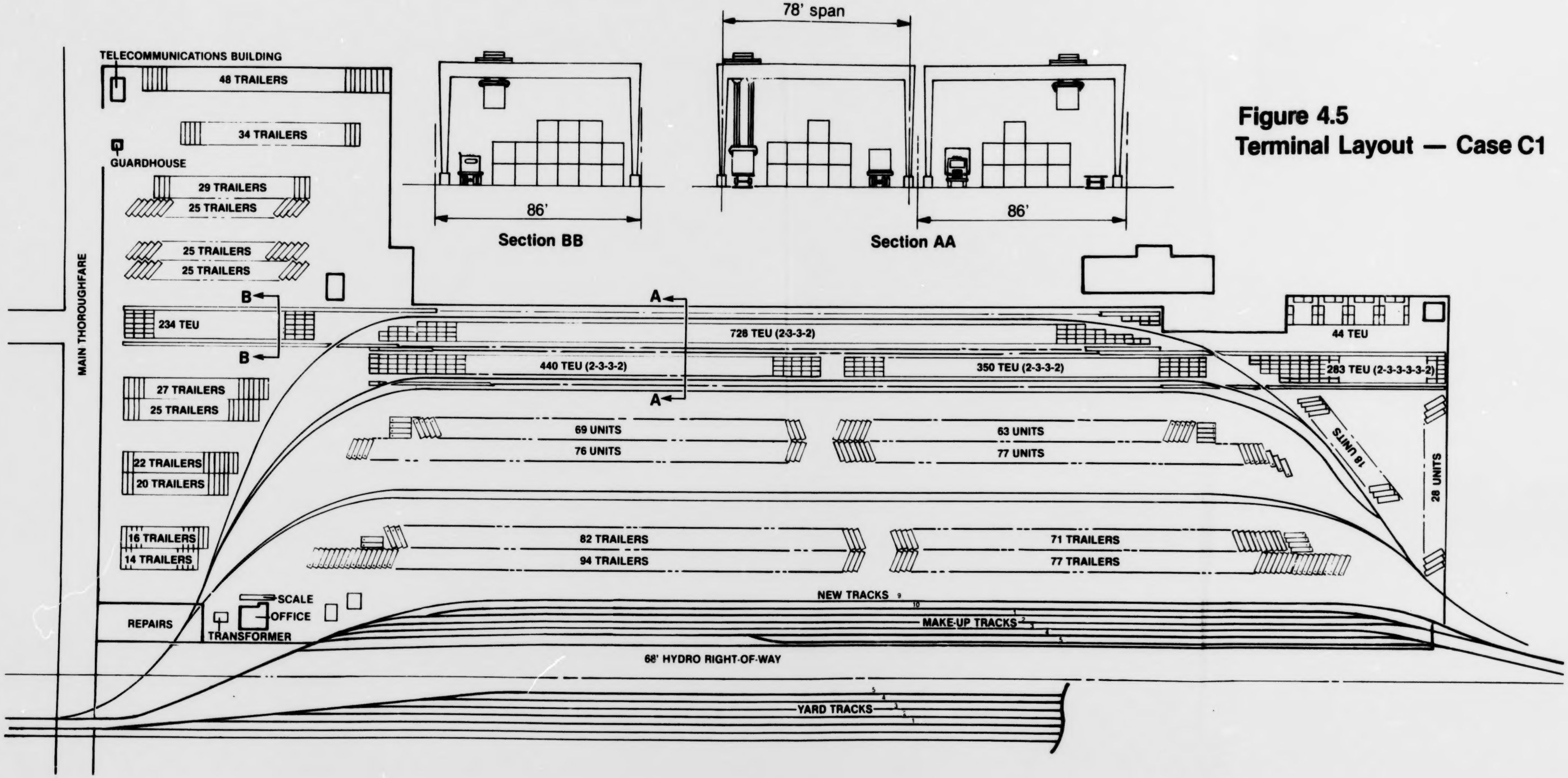

78' span
86'
Section BB
86'
Section AA
TELECOMMUNICATIONS BUILDING
48 TRAILERS
34 TRAILERS
GUARDHOUSE
29 TRAILERS
25 TRAILERS
25 TRAILERS
25 TRAILERS
MAIN THOROUGHFARE
B
B
A
A
234 TEU
728 TEU (2-3-3-2)
44 TEU
440 TEU (2-3-3-2)
350 TEU (2-3-3-2)
283 TEU (2-3-3-3-3-2)
27 TRAILERS
25 TRAILERS
69 UNITS
76 UNITS
63 UNITS
77 UNITS
18 UNITS
28 UNITS
22 TRAILERS
20 TRAILERS
16 TRAILERS
14 TRAILERS
82 TRAILERS
94 TRAILERS
71 TRAILERS
77 TRAILERS
SCALE
OFFICE
REPAIRS
TRANSFORMER
NEW TRACKS
MAKE-UP TRACKS
68' HYDRO RIGHT-OF-WAY
YARD TRACKS

Figure 4.5
Terminal Layout — Case C1

For the purpose of the economic analysis, it is assumed that the off-site area will require 9 acres, the additional 2.70 acres being required for administrative purposes.

The storage and track requirements compared to the facilities made available in Figure 4.5 are presented below:

Table 4.15 Case C1 Track and Storage Requirements versus Availability

	Track			Storage				
	Required	Available	Turns		Available			
Service	(feet)	(feet)	Per Day	Required	Working Area	Remote On-site	Remote Off-site	Total
Marine Containers	11,467	3,400	3.4					
- loaded (TEU)				2,133	1,518	615	-	2,133
- empty (TEU)				2,267	-	-	2,267	2,267
Domestic Containers	14,133	4,330	3.3					
- loaded (units)				333	285	46	-	331
- empty (units)				267	-	-	267	267
- chassis (units)				100	-	100	-	100
Trailers	20,533	4,410	4.7					
- all (units)				613	324	310	-	634
Total Track	46,133	12,140	3.8					
Total Trailers, Loaded Domestic Containers and Chassis				1,046	609	456	-	1,065
External Tracks								
- make-up	10,850							
- yard	15,750							
- dump	7,000							
	33,600							

The basic handling machinery requirements for this case are as follows:

Table 4.16 Basic Handling Equipment Requirements - Case C1

Activity	Annual Volume (units)	Handling Factor (Per 10,000 units)	Peak Day Units	Peak Period Units	Peak Period Handlings	Machines Required
Unloading						
- trailers	133,333	1.889	252	227	72	3.2 packers
- domestics	133,333	1.500	200	180	51	3.5 toplifters
- marines	133,333	2.651	353	318	48	6.6 060 cranes
Loading						
- trailers	133,333	2.675	357	268	120	2.2 packers
- domestics	133,333	2.227	297	223	90	2.5 toplifters
- marines	133,333	1.750	233	210	72	2.9 060 cranes

(1) applying the percentages presented in Table 4.3
(2) see Table 4.4

These basic requirements must be augmented as follows:

- An additional toplifter will be required to assist the most easterly 060 crane at the north end of the terminal. This unit would transfer loaded marine containers from the crane runway into storage and would load chassis with loaded marine containers when required.

- The addition of the equivalent of 1-060 crane would be required to compensate for the "long travel" which the cranes on the west lane and east lane will encounter in moving loaded marine containers from the railcars to the south remote area and the north remote area respectively.

- Three light capacity toplifters would be required to handle the empty marine and Domestic Containers in the remote off-site storage area. This number includes the allowance for maintenance. These three units would operate on a single shift basis only.

The total equipment requirements (including an allowance of 20 percent for maintenance) are, therefore, 4 piggypackers, 9-060 cranes, and 9 toplifters for the peak unloading periods. For the loading periods, 3 piggypackers, 5-060 cranes, and 8 toplifters will be required. Three toplifters may be light capacity models. Thirty-one machine operators would be required.

The hostling tractor requirements are developed below:

Table 4.17 Hostling Tractor Requirements - Case C1

Activity	Peak Period Units	Peak Hour Units	Working Area		Remote Area		Weighted Average Rate	Tractors Required
			Handling Rate	Unit Storage	Handling Rate	Unit Storage		
Unloading								
- trailers	227	75.6	30.0	324	20.0	289	25.3	2.99
- domestics	180	60.0	20.0	285	13.0	148	17.6	3.41
								6.40
Loading								
- trailers	268	53.6	30.0	324	20.0	289	25.3	2.12
- domestics	223	44.6	16.0	285	11.4	148	14.4	3.10
								5.22

Adding the 25 percent for dispatching delays as before results in a total requirement for 8 tractors for the peak unloading periods. For the peak loading periods, 7 tractors are required. Fifteen tractor drivers are required.

2.6 Case C2

This case represents the conversion of Terminal 'X' into a transfer terminal by the installation of 030 cranes. Remote off-site storage will be provided for the empty Domestic Containers and all of the marine containers with remote on-site storage for most of the loaded Domestic Containers and chassis (some short-term storage is available in the working area). Figure 4.6 presents the layout for this case which shows the number and location of the cranes. There are no toplifters or piggypackers used at the terminal; however, they are required at the remote off-site location to handle the empty marine and Domestic Containers.

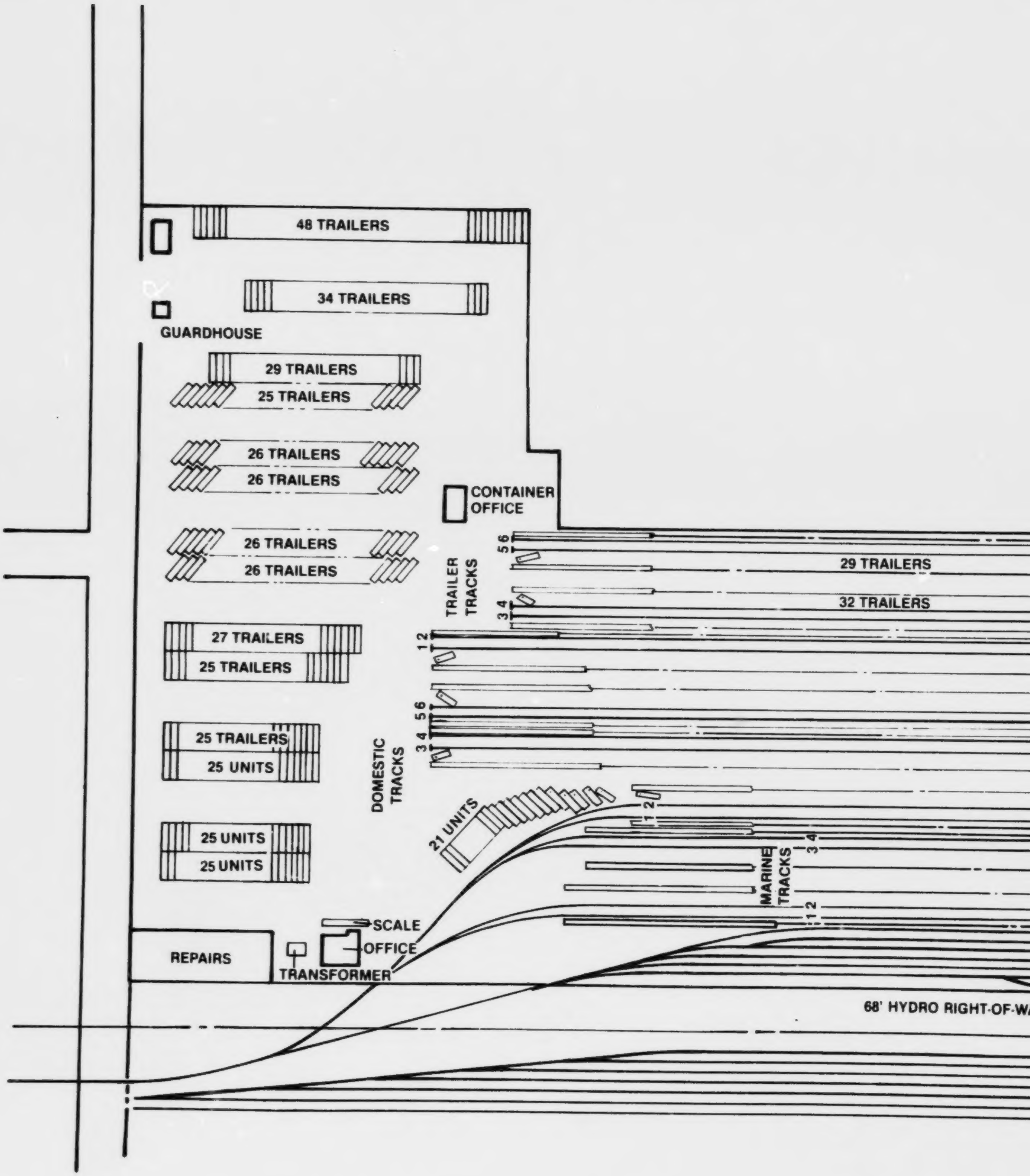
The comparison between the storage and trackage requirements and the features provided in the layout are as follows:

Table 4.18 Case C2 Track and Storage Requirements versus Availability

	Track			Storage				
					Available			
Service	Required (feet)	Available (feet)	Turns Per Day	Required	Working Area	Remote On-site	Remote Off-site	Total
Marine Containers	11,467	7,120	1.6					
- loaded (TEU)				2,133	-	-	2,133	2,133
- empty (TEU)				2,267	-	-	2,267	2,267
Domestic Containers	14,133	10,930	1.3			(1)		
- loaded (units)				333	220	123	-	343
- empty (units)				267	-	-	267	267
- chassis (units)				100		100	-	100
Trailer	20,533	9,970	2.1			(2)		
- all (units)				613	234	381	-	615
Total Track	46,133	28,020	1.6					
Total Trailers, Loaded Domestic Containers and Chassis.				1,046	454	604		1,058
External Tracks								
- make-up	9,950							
- yard	14,250							
- dump	3,450							
	27,650							

(1) 130 in north side remote storage area and 96 in south side remote area

(2) south side remote storage area


48 TRAILERS
34 TRAILERS
GUARDHOUSE
29 TRAILERS
25 TRAILERS
26 TRAILERS
26 TRAILERS
CONTAINER OFFICE
26 TRAILERS
26 TRAILERS
5 6
29 TRAILERS
TRAILER TRACKS
3 4
32 TRAILERS
1 2
27 TRAILERS
25 TRAILERS
5 6
25 TRAILERS
25 UNITS
3 4
DOMESTIC TRACKS
1 2
21 UNITS
1 2
25 UNITS
25 UNITS
3 4
MARINE TRACKS
1 2
SCALE
OFFICE
REPAIRS
TRANSFORMER
68' HYDRO RIGHT-OF-WA

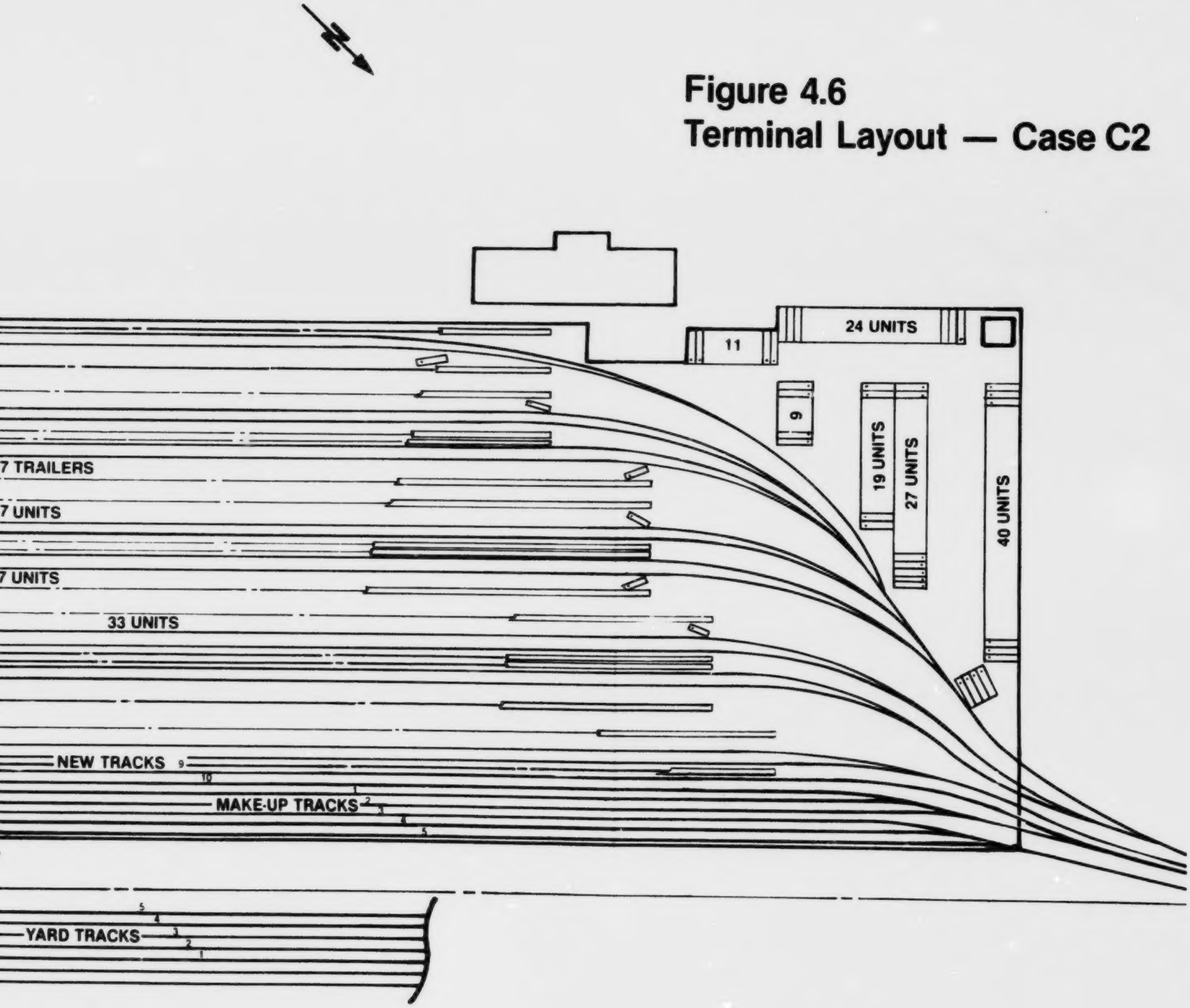

N
24 UNITS
11
9
19 UNITS
27 UNITS
40 UNITS
7 TRAILERS
7 UNITS
7 UNITS
33 UNITS
NEW TRACKS
9
10
MAKE-UP TRACKS
1
2
3
4
5
YARD TRACKS
5
4
3
2
1

Figure 4.6
Terminal Layout — Case C2

When in operation, the north side remote storage area will be dedicated to loaded Domestic Containers on chassis and the south side will be split between Domestic Containers and trailers. The domestic empty chassis will again be stored on the hydro easement.

Because of the relatively low turnaround required for the terminal tracks, one yard engine operating 3 shifts per day should be able to handle the switching duties. The access provided to the south end of the make-up and yard tracks for marine tracks 1-4 and domestic tracks 1-2 should help to alleviate some of the conflicting movements which can occur when the road units are switching the make-up and yard tracks. The existing yard and make-up tracks have enough length to handle the 400,000 units without the expansion required in Case C1. Also, the grade separation at the main thoroughfare will not be required as most of the switching will occur at the north end of the terminal.

The area required for remote off-site storage, assuming that toplifters are used to stack the empty containers in 4 X 4 piles and loaded containers in 2 X 2 piles, is determined from the factors developed in Section 1.3 and Appendix 4.3.3 as follows:

Empty marine containers:
2,267 TEU X 82 sq. ft./TEU X 1.15 = 213,778 sq. ft. = 4.91 acres

Loaded marine containers:
2,133 TEU X 231.2 sq. ft./TEU X 1.15 = 567,122 sq. ft. = 13.02 acres

Empty Domestic Containers:
267 units X 196.8 sq. ft./unit X 1.15 = 60,427 sq. ft. = 1.39 acres

Trailers:
198 X 1000 sq.ft./unit = 198,000 sq.ft. = 4.55 acres

23.87 acres

For the purpose of the economic analysis, it is assumed that 27 acres will be required for the off-site area, the additional 3.13 acres being required for administrative purposes.

The basic equipment handling machinery requirements for this case are as follows:

Table 4.19 Basic Handling Equipment Requirements - Case C2

Activity	Annual Volume (units)	Handling Factor (Per 10,000 units)	Peak Day Units	Peak Period Units (1)	Peak Period Handlings (2)	Machines Required
Unloading						
- trailers	133,333	1.889	252	227	72	3.2 030 cranes
- domestics	133,333	1.500	200	180	60	3.0 030 cranes
- marines	133,333	2.651	353	318	100	3.2 030 cranes
Loading						
- trailers	133,333	2.675	357	268	120	2.2 030 cranes
- domestics	133,333	2.227	297	223	90	2.5 030 cranes
- marines	133,333	1.750	233	210	108	1.9 030 cranes

(1) applying the percentages presented in Table 4.3
(2) see Table 4.4

These basic requirements must be augmented as follows:

- five toplifters will be required in the remote off-site storage in order to handle the loaded marine containers being shuttled into it from the main terminal. These units may also be used during the non-peak hours to handle the empty marine and Domestic Containers stored here.

The total requirements (including 20 percent for maintenance) are, therefore, 12-030 cranes and 6 toplifters for the peak unloading periods and 8-030 cranes and 6 toplifters for the peak loading periods. Twenty-nine machine operators are required.

The hostling tractor requirements are developed below:

Table 4.20 Hostling Tractor Requirements - Case C2

			Working Area		Remote Area			
Activity	Peak Period Units	Peak Hour Units	Handling Rate	Unit Storage	Handling Rate	Unit Storage	Weighted Average Rate	Tractors Required
Unloading								
- trailers	227	75.6	40.0	234	20.0	379	27.6	2.74
- domestics	180	60.0	20.0	220	13.0	213	16.6	3.61
								6.35
Loading								
- trailers	268	53.6	40.0	234	20.0	379	27.6	1.94
- domestics	223	44.6	16.0	220	11.4	213	13.7	3.26
								5.20

Adding the 25 percent for dispatching delays as in previous cases results in a total requirement for 7 tractors for the peak loading period and 8 tractors for the peak unloading period. Fifteen tractor drivers are required.

2.7 Shuttling to Remote Off-Site Storage

Shuttling to a remote off-site storage area is required for Cases C1 and C2 because there is insufficient land available at the main terminal. Some shuttles can be handled during the non-peak hours by the hostling tractors working in the main terminal. The balance must be handled by additional shuttle tractors.

In order to determine the number of units to be shuttled, the following patterns were determined from recent observations at the terminal and from Tables 2.2 and 2.3 of Appendix 1.

Table 4.21 Loaded:Empty Ratios for Containers

Service		Source	Loaded	Empty	Loaded: Empty
Domestics	- inbound	Table 4.2	17,049	15,951	52:48
	- outbound	Table 4.3	33,000	0	100:0
Marines	- inbound	Recent	12,600	2,044	86:14
	- outbound	observations	10,571	3,973	73:27

These ratios can be applied to the peak daily handlings developed in Tables 4.16 and 4.19 in order to determine the shuttling requirements for the two cases as follows:

Table 4.22 Shuttling Requirements - Cases C1 and C2

Case	Activity	Peak Daily Units	Percent to be Shuttled	Units to be Shuttled	Trailer Loads to be Shuttled
C1	Domestic empties - inbound	200	48	96 units	96 loads
	Marine empties - inbound	353	14	49 units	32 loads (1)
				145 units	128 loads
	Marine empties - outbound	233	27	63 units	41 loads (1)
C2	Domestic empties - inbound	200	48	96 units	96 loads
	Marines - inbound	353	100	353 units	230 loads (1)
	Trailers - inbound	252	32 (2)	81 units	81 loads
				530 units	407 loads
	Marines - outbound	233	100	233 units	151 loads (1)
	Trailers- outbound	252	32 (2)	81 units	81 loads
				314 units	232 loads

(1) The ratio of 20-foot containers to 40-foot containers is assumed to be 70:30. Two TEU can be shuttled with one tractor.

(2) The ratio of off-site storage to total storage in Table 4.18 is used here (198 ÷ 613 = 0.32).

Because each hostling tractor is not required for its entire 8-hour shift, even on peak days, there is some time available with which to assist in the shuttling operations. The daily non-peak hours are between the end of the morning rail car unloading (0900-1000 hours) until the evening railcar loadings become heavy (1600 hours). The time available to assist in the shuttling operations is limited, therefore, to the morning unloading shifts and approximately 3 hours are available per hostling tractor.

If each tractor can be expected to make one round trip to the remote storage area in 30 minutes, the hostling tractors may be expected to make 6 trips per day and the dedicated shuttling tractors 14 trips per shift. The requirements for shuttling tractors is developed for the 2 cases as follows:

Table 4.23 Basic Shuttling Tractor Requirements - Cases C1 and C2

Case	Loads to be Shuttled	Hostling Tractors		Shuttling Required	
		Operating	Loads Handled	Loads	Tractors
C1	128	8	48	80	5.7
C2	407	10	60	347	24.8

Because it will be less expensive to pay a little overtime on the peak day for marine containers rather than buy extra chassis for two days of the week, Table 4.24 has been modified by increasing the shuttling tractor capacity to 18 trips per peak shift as follows:

Table 4.24 Peak Shuttling Tractor Requirements - Cases C1 and C2

Case	Loads to be Shuttled	Hostling Tractors		Shuttling Required	
		Operating	Loads Handled	Loads	Tractors
C1	128	8	48	80	4.4
C2	407	10	60	347	19.3

The shuttling requirements are, therefore, 5 tractors for Case C1 and 20 for Case C2.

2.8 Conclusions Regarding Cases C1 and C2

Again both of these cases will require a vastly improved management information system in order to operate efficiently. This requirement becomes even more apparent when one considers the fact that 2 separate areas must be controlled and coordinated rather than the single facility as in Cases B1 and B2.

From the numbers of pieces of handling equipment and hostling and shuttling tractors determined in the previous sections, it is apparent that Case C1 is more cost effective because of the improved storage available in the working area. For this reason, it can be stated as a generalization that the integrated terminals with storage in the working area are more space efficient and have lower costs than the transfer terminals.

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2.9 Case C3

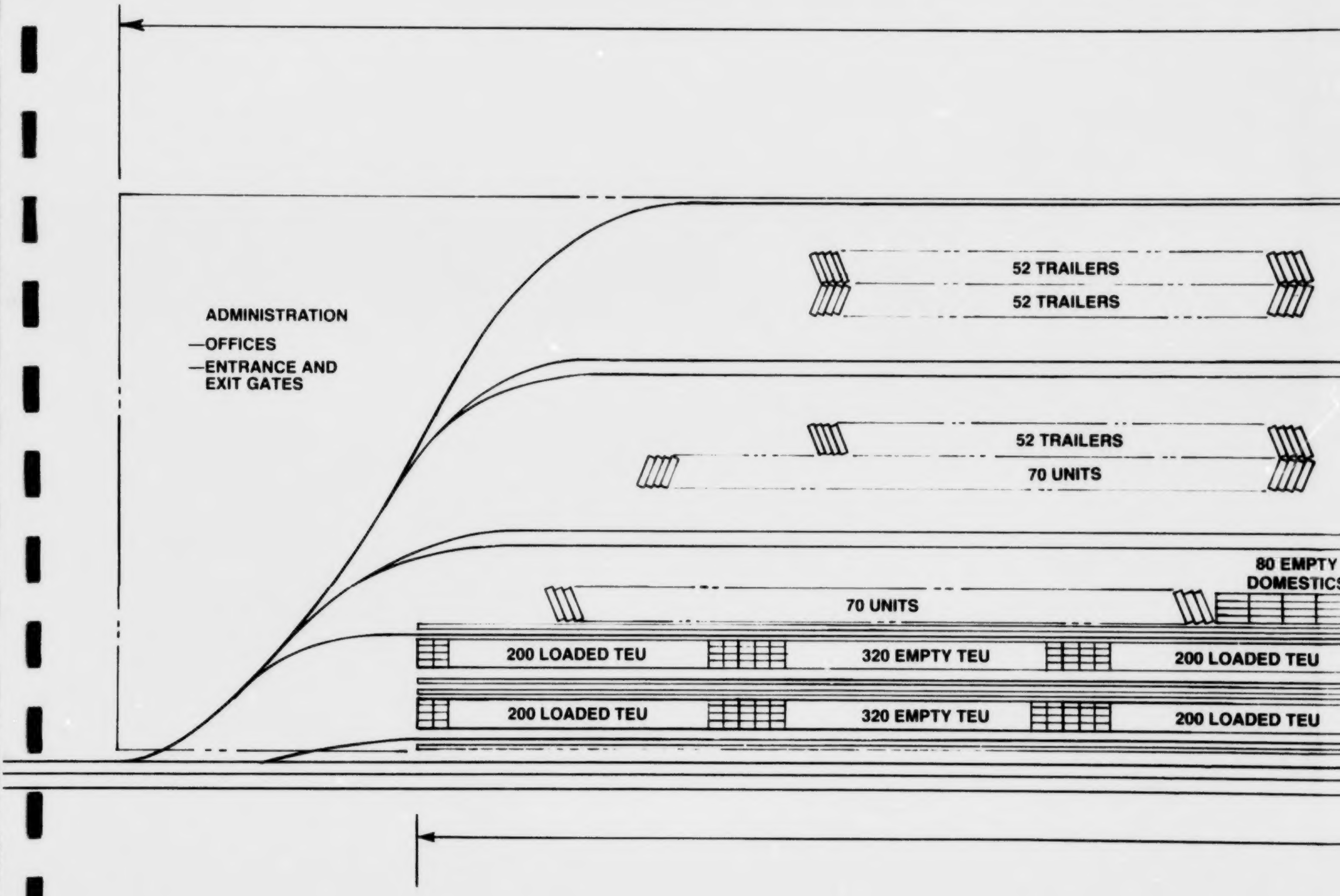
This case represents a terminal designed using some of the findings mentioned above and constructed on a new site custom built to handle 400,000 units per year. It is based on the assumption that land is available in a location with the same relative proximity to the industrial centre of the metropolitan area so that there is no additional penalty for pick-up and delivery. It further assumes that the site parallels the railway main line and that no additional transfer or switching penalties will be incurred. It is designed using 060 cranes for handling marine containers even though this option is more expensive than the one using toplifters (see Section 4.3 for the breakeven analysis). The case discussed in the next section (C4) uses toplifters for both marine and Domestic Containers. This comparison has been used to show the cost effectiveness of one design versus the other.

Each terminal configuration should be designed to reflect its specific traffic mix. In this case, the split of one-third each for trailers, marine containers, and Domestic Containers results in the trackage and storage capacity requirements shown in Table 4.25. If a design factor of 2 track turns per day is selected, the following trackage and storage areas are required.

Table 4.25 Trackage and Storage Requirements - Case C3

Service	Needed (feet)	Turns per Day	Design (feet)	Number of Tracks	Average Length (feet)	Units Required	Configuration	Length of Track (feet)
Marines	11,467	2.0	5,734	2	2,867			
- loaded (TEU)						2,131	10	2291
- empty (TEU)						2,267	16	1523
								3814
Domestics	14,133	2.0	7,067	2	3,533			
- loaded (units)						333	8/100'	2081
- empty (units)						267	16	384
- chassis (units)						100	8/100'	625
								3090
Trailers	20,533	2.0	10,267	3	3,422			
- all (units)						613	8/100'	2554
Total Track	46,133		23,068					

Figure 4.7 illustrates one possible layout which satisfies the throughput requirements. It is very similar to the layout proposed in Case C1 with the exception that all storage of empty and loaded containers and trailers is located within the working area. This design feature is based upon the findings of the previous section and thus, eliminates the need for shuttling and minimizes the hostling requirements.


ADMINISTRATION
—OFFICES
—ENTRANCE AND EXIT GATES
52 TRAILERS
52 TRAILERS
52 TRAILERS
70 UNITS
80 EMPTY DOMESTIC
70 UNITS
200 LOADED TEU
320 EMPTY TEU
200 LOADED TEU
200 LOADED TEU
320 EMPTY TEU
200 LOADED TEU

SUMMARY

	TRACK				STORAGE	
	LENGTH REQUIRED	NO. OF TRACKS	LENGTH PROVIDED	TURNS PER DAY	REQUIRED	PROVIDED
MARINES	11,467 FT.	2	7,800 FT.	1.5	4,400	4,402
DOMESTICS	14,133 FT.	2	7,200 FT.	2.0	700	732
TRAILERS	20,533 FT.	3	10,400 FT.	2.0	613	624

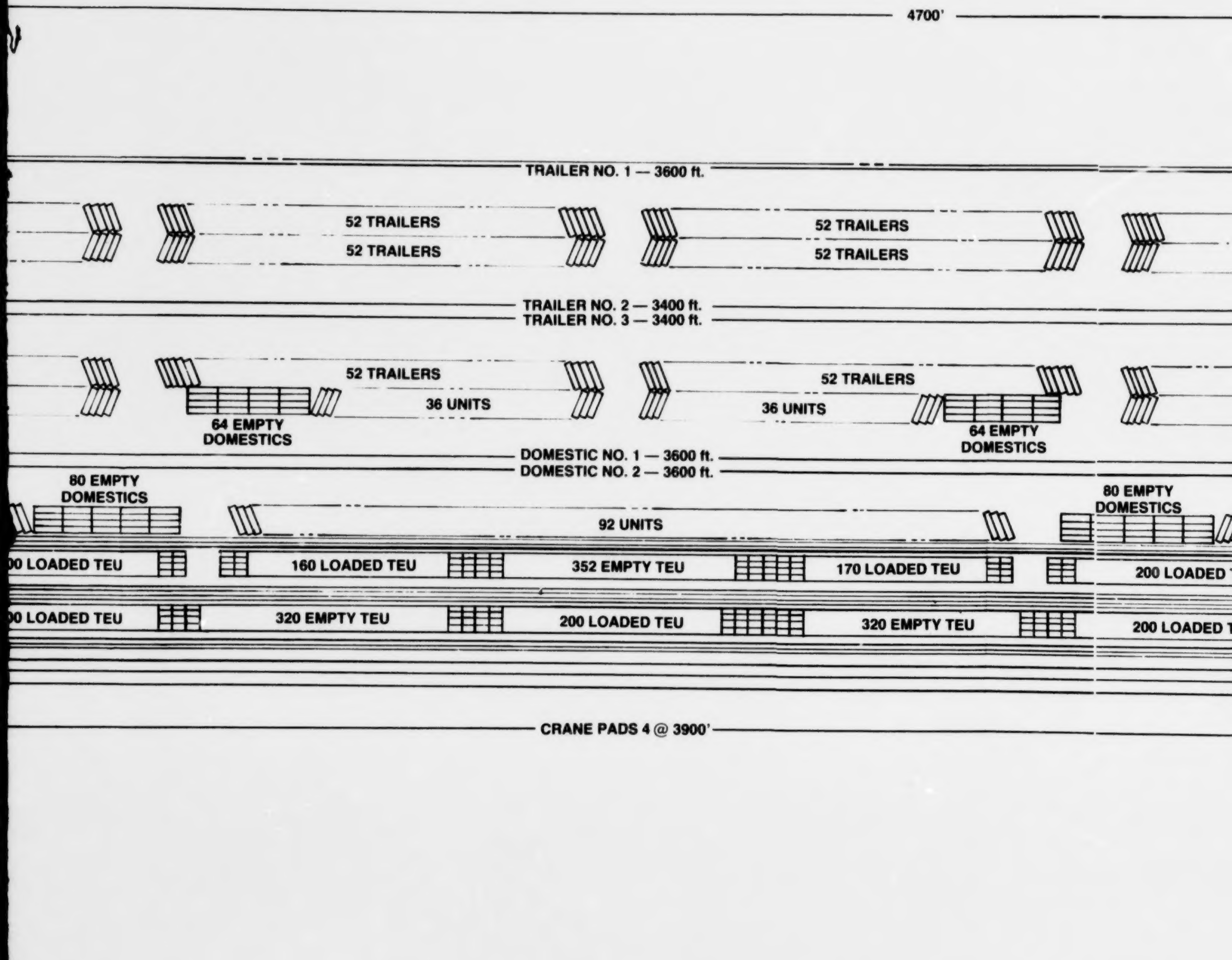
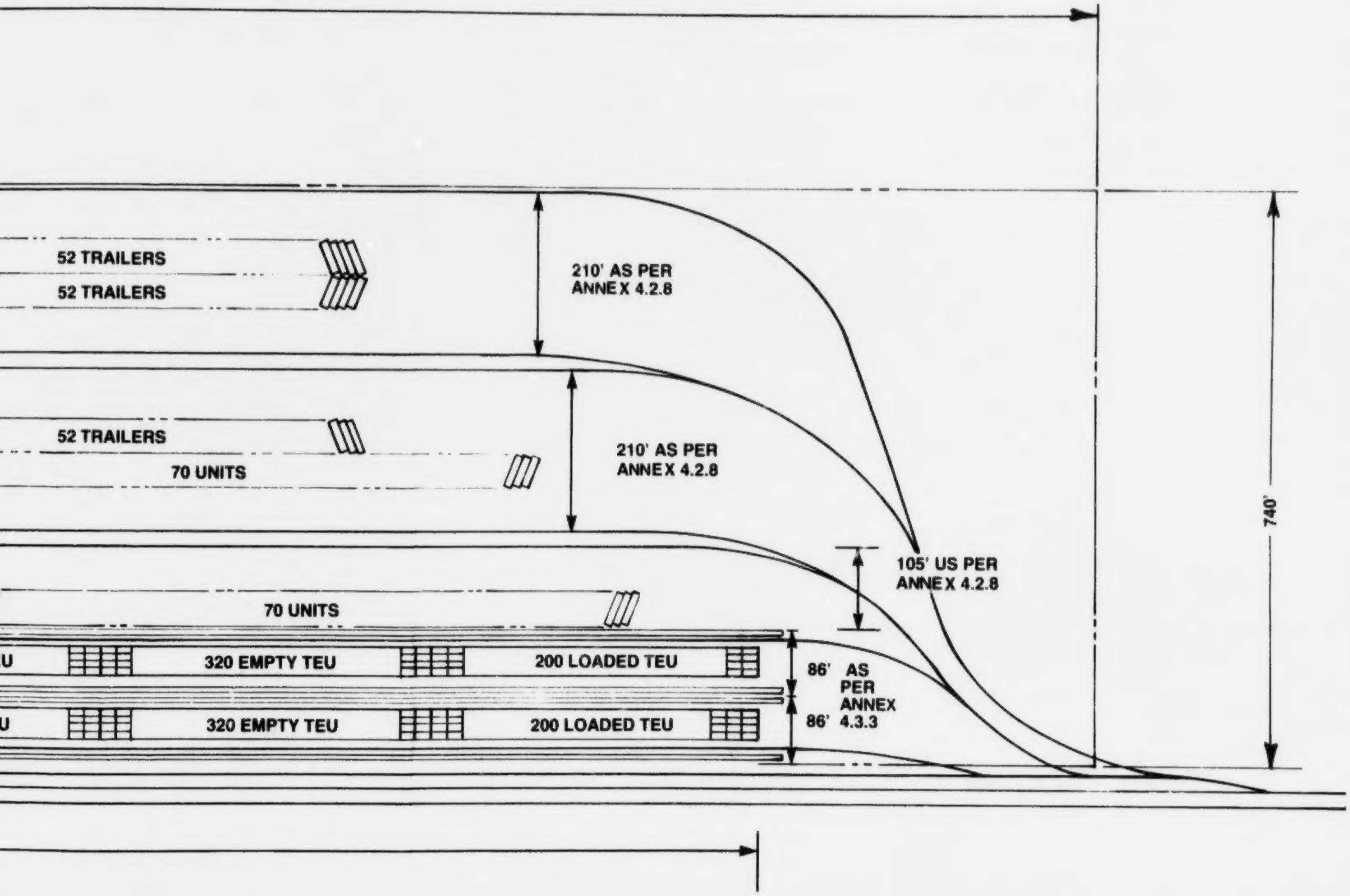

4700'
TRAILER NO. 1 — 3600 ft.
52 TRAILERS
52 TRAILERS
52 TRAILERS
52 TRAILERS
TRAILER NO. 2 — 3400 ft.
TRAILER NO. 3 — 3400 ft.
52 TRAILERS
36 UNITS
64 EMPTY DOMESTICS
52 TRAILERS
36 UNITS
64 EMPTY DOMESTICS
DOMESTIC NO. 1 — 3600 ft.
DOMESTIC NO. 2 — 3600 ft.
80 EMPTY DOMESTICS
92 UNITS
80 EMPTY DOMESTICS
00 LOADED TEU
160 LOADED TEU
352 EMPTY TEU
170 LOADED TEU
200 LOADED
00 LOADED TEU
320 EMPTY TEU
200 LOADED TEU
320 EMPTY TEU
200 LOADED
CRANE PADS 4 @ 3900'

Figure 4.7
Terminal Layout—Case C3


52 TRAILERS
52 TRAILERS
210' AS PER ANNEX 4.2.8
52 TRAILERS
70 UNITS
210' AS PER ANNEX 4.2.8
105' US PER ANNEX 4.2.8
70 UNITS
U
320 EMPTY TEU
200 LOADED TEU
U
320 EMPTY TEU
200 LOADED TEU
86' AS PER ANNEX 4.3.3
86'
740'

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The basic handling equipment requirements are the same as those determined for Case C1 (see Table 4.16). The basic requirements determined in Table 4.16 do not need augmenting as all of the storage is in the working area. The total equipment requirements (including an allowance of 20 percent for maintenance) are, therefore, 4 piggypackers, 5 toplifters, and 8-060 cranes for the peak unloading periods and 3 piggypackers, 3 toplifters, and 4-060 cranes for the peak loading period. Twenty-five machine operators are required.

The hostling tractor requirements are determined as in previous cases as follows:

Table 4.26 Hostling Tractor Requirements - Case C3

Activity	Peak Period Units	Peak Hour Units	Working Area Handling Rate	Tractors Required
Unloading				
- trailers	227	75.6	30.0	2.52
- domestics	180	60.0	20.0	3.00
				5.52
Loading				
- trailers	268	53.6	30.0	1.79
- domestics	223	44.6	16.0	2.79
				4.58

Adding the 25 percent for dispatching delays results in a total requirement for 6 tractors for the peak loading period and 7 tractors for the peak unloading period. Thirteen tractor drivers are required.

2.10 Case C4

This case is identical to Case C3 except that toplifters are used to handle marine containers rather than 060 cranes. Figure 4.8 illustrates one possible terminal layout based upon the premise that loaded marine containers are stacked in 2 X 2 piles to allow for selective retrieval while empty marine containers are block stacked in 3 X 4 high piles.

The handling equipment requirements must be re-calculated as follows:

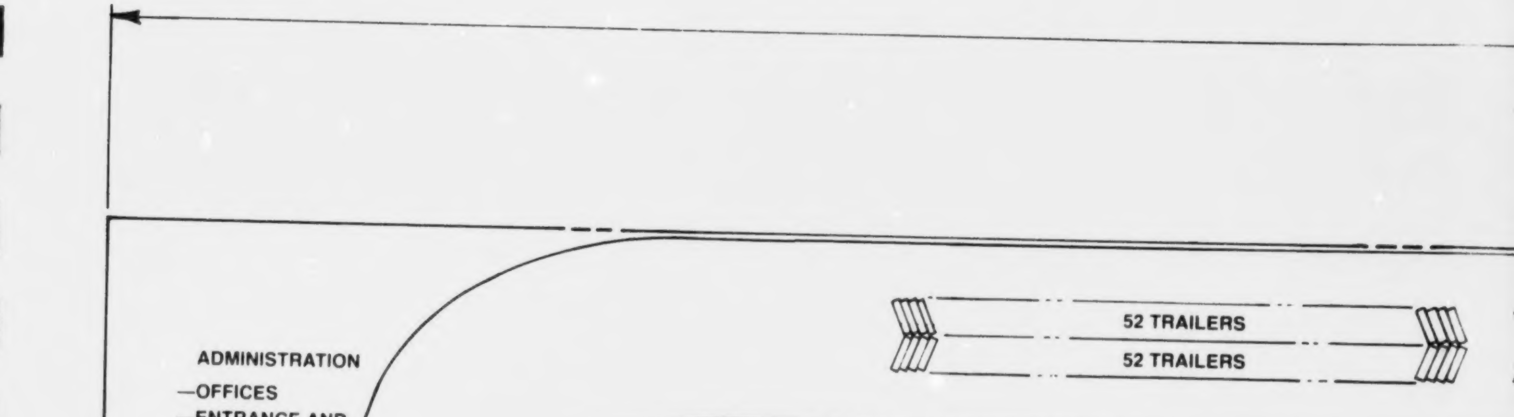
ADMINISTRATION
—OFFICES
—ENTRANCE AND EXIT GATES
52 TRAILERS
52 TRAILERS
52 TRAILERS
70 UNITS
80 EMPTY DOMESTICS
70 UNITS
232 LOADED TEU (2 HIGH)
112 LOADED TEU (2 HIGH)
576 EMPTY TEU (4 HIGH)
576 EMPTY TEU (4 HIGH)

Figure 4.8
Terminal Layout—Case C4

SUMMARY

	TRACK				STORAGE	
	LENGTH REQUIRED	NO. OF TRACKS	LENGTH PROVIDED	TURNS PER DAY	REQUIRED	PROVIDED
MARINES	11,467 FT.	2	7,550 FT.	1.5	4,400	4,436
DOMESTICS	14,133 FT.	2	7,200 FT.	2.0	700	732
TRAILERS	20,533 FT.	3	10,400 FT.	2.0	613	624

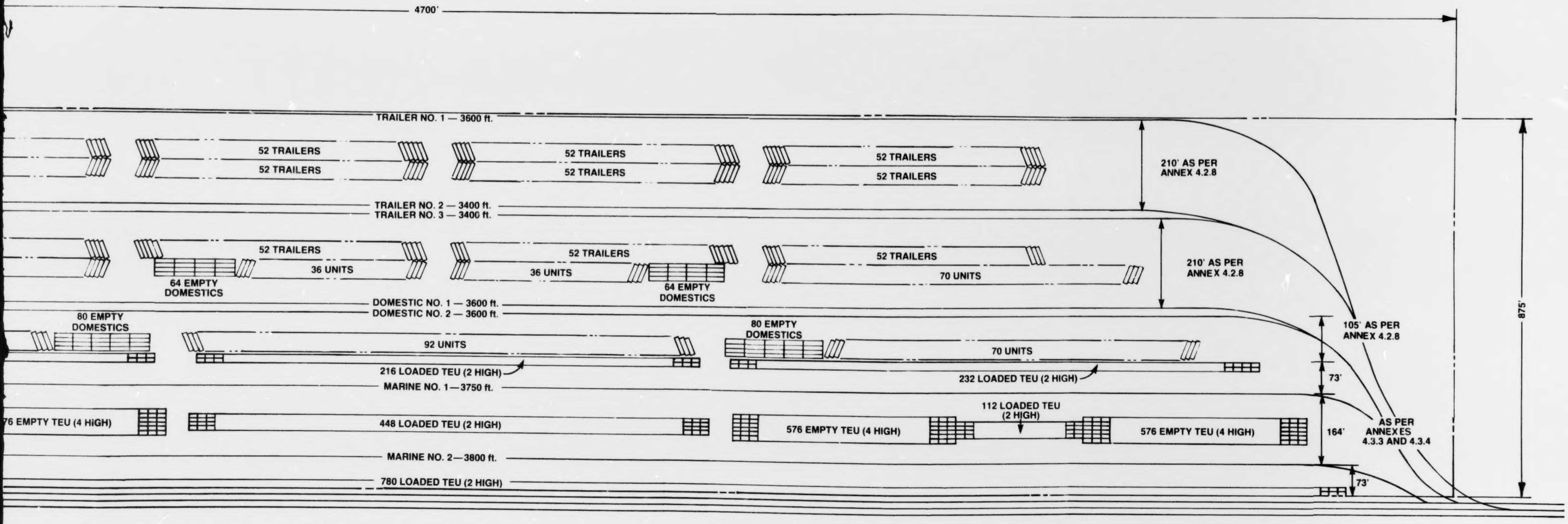
4700'
TRAILER NO. 1 — 3600 ft.
52 TRAILERS
52 TRAILERS
52 TRAILERS
52 TRAILERS
52 TRAILERS
52 TRAILERS
210' AS PER ANNEX 4.2.8
TRAILER NO. 2 — 3400 ft.
TRAILER NO. 3 — 3400 ft.
52 TRAILERS
36 UNITS
64 EMPTY DOMESTICS
52 TRAILERS
36 UNITS
64 EMPTY DOMESTICS
52 TRAILERS
70 UNITS
210' AS PER ANNEX 4.2.8
875'
DOMESTIC NO. 1 — 3600 ft.
DOMESTIC NO. 2 — 3600 ft.
80 EMPTY DOMESTICS
92 UNITS
216 LOADED TEU (2 HIGH)
80 EMPTY DOMESTICS
70 UNITS
232 LOADED TEU (2 HIGH)
105' AS PER ANNEX 4.2.8
73'
MARINE NO. 1—3750 ft.
76 EMPTY TEU (4 HIGH)
448 LOADED TEU (2 HIGH)
576 EMPTY TEU (4 HIGH)
112 LOADED TEU (2 HIGH)
576 EMPTY TEU (4 HIGH)
164'
AS PER ANNEXES 4.3.3 AND 4.3.4
MARINE NO. 2—3800 ft.
780 LOADED TEU (2 HIGH)
73'

Table 4.27 Basic Handling Equipment Requirements - Case C4

Activity	Annual Volume (units)	Handling Factor (Per 10,000 units)	Peak Day Units	Peak Period Units (1)	Peak Period Handlings (2)	Machines Required
Unloading						
- trailers	133,333	1.889	252	227	72	3.2 packers
- domestics	133,333	1.500	200	180	51	3.5 toplifters
- marines	133,333	2.651	353	318	55	5.8 toplifters
Loading						
- trailers	133,333	2.675	357	268	120	2.2 packers
- domestics	133,333	2.227	297	223	90	2.5 toplifters
- marines	133,333	1.750	233	210	96	2.2 toplifters

(1) applying the percentages presented in Table 4.3

(2) see Table 4.4

The total equipment requirements (including an allowance of 20 percent for maintenance) are, therefore, 4 piggypackers and 12 toplifters for the peak unloading periods. For the peak loading periods, 3 piggypackers and 6 toplifters are required. Twenty-two machine operators are required.

The hostling tractor requirements are the same as in Case C3.

2.11 Summary of the Cases Studied

The development of the various cases in the previous sections follows the development of handling technologies available as the volumes have grown (and are expected to grow) for Terminal 'X'. Case A presents an analysis of a moderate size terminal (100,000 units per year) utilizing first generation technology - ramps and toplifters. As the volume of traffic increases towards the present levels of 150,000 units per year, the high space and switching requirements of the ramp layout become so restrictive for the area available that the empty annex is required and the requirements for shuttling and hostling increase substantially.

The introduction of piggypackers for handling trailers allows a much more space efficient layout to be installed. The space and yard switching savings are such that the existing site is adequate for an annual throughput in excess of 200,000 units per year without requiring a remote off-site area for the storage of empty containers.

Further increases in traffic volumes to the 400,000 units per year level strain the capacity of the existing site to the limit, even with the introduction of high density 060 cranes for handling marine containers. The capacity of the existing facility appears to be approximately 225,000 units per year based upon the space required for Case B1. Beyond this limit, the use of a remote off-site storage is required and consideration should be given to a new site based upon the layout presented for Case C4.

One of the greatest advantages of providing a run-through integrated terminal with sufficient trackage to keep the turnaround to a maximum of 2.0 is that it allows the road locomotives to handle a good portion of the terminal switching and helps to reduce the use of switch engines at the terminal. The use of road locomotives to double or triple their trains at the terminal will work only at high volume levels which in turn will allow the operation of more single or double destination trains.

An alternative to a new site for all traffic would be a splitting of the traffic handled at the existing terminal and at a new site, either by service (marine containers at one site and trailers and Domestic Containers at the other) or by destination (east at one and west at the other). This study does not, however, consider the split terminal concept further.

3. COST MODEL

The annual cost of any terminal operation is composed of 2 basic elements, the annual operating costs and the annual carrying charges for the asset investments. Both of these elements are discussed in the sections following with the attendent assumptions used.

The cost factors of any terminal are not large; however, the size, configuration, and operating practices employed at the terminal will affect the costs of related non-terminal activities. Such related activities are pick-up and delivery charges which are reduced on a unit basis by the introduction of the computer-based management systems and terminal switching charges which are assumed to be part of the railway cost structure. Terminal transfer costs by the yard engines for those cars moving in mixed train services are considered to be part of the railway costs and are not considered further in this study.

On the asset side only the terminal and make-up tracks are considered to be a part of the terminal operation while the yard tracks, storage tracks, (the auxiliary car storage area, etc.) and the main lines are considered to be part of the railway asset investment. Likewise, only a portion of the investment in the computer-based management system has been attributed to the terminal under consideration (see Section 5.6, Appendix I1).

3.1 Terminal Asset Carrying Charges

The annual carrying charges of the various specific assets required for the terminal are determined by applying current value cost of capital (CVCOC) factors to each asset based upon its present purchase price. These factors assume a cost of debt of 16.5 percent, a cost of equity of 22.3 percent, a debt:equity ratio of 71:29 and a corporate tax rate of 51.4 percent. The specific CVCOC factors are a function of the life of the asset, its end of life salvage value, its CCA rate, and its tax treatment. The following table shows the assumptions made concerning these assets and their CVCOC factors.

Table 4.28 CVCOC Factors for Terminal Assets

Asset	Life (years)	Salvage (%)	CCA (%)	Tax (note)	CVCOC Factor
Land	-	-	-	-	0.18383
Buildings - offices, garages	50	10	5	1	0.16893
- gate booths	25	0	10	1	0.17309
Site Preparation	100	0	4	2	0.15852
Paving - asphalt, crane pads	10	0	8	1	0.26976
Tracks, Switches	50	12	4	2	0.16078
Ramps	10	0	8	1	0.26976
Improvements- fencing	25	0	10	1	0.17309
- flood lights	50	12	5	1	0.16890
- weigh scales	50	12	4	2	0.16078
- hydro substations	33	5	6	1	0.17277
- tarps	5	0	30	1	0.37068
- compressors	42	0	20	2	0.13362
- fuel storage	50	10	10	1	0.15673
Communications	15	10	20	1	0.18379
Computers	10	0	30	1	0.22138
Equipment	10	10	30	2	0.19929
Underpass	50	0	4	2	0.16096

Note 1 = where standard declining balance CCA applies

Note 2 = where standard declining balance CCA and 7 percent Investment Tax Credit apply.

The capital cost estimates for the cases under consideration and their annual capital carrying charges are presented in Table 4.29. These annual charges are included in the annual operating costs discussed in the following section.

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Table 4.29 Capital Cost Estimates ($1,000) - All Cases

Asset	Unit Cost	Present 150,000 Units		Case A 100,000 Units		Case B1 200,000 Units		Case B2 200,000 Units		Case C1 400,000 Units		Case C2 400,000 Units		Case C3 400,000 Units		Case C4 400,000 Units	
		U	$	U	$	U	$	U	$	U	$	U	$	U	$	U	$
1) Land	$200,000/acre	61	12,200	40	8,000	51	10,200	51	10,200	60	12,000	78	15,600	80	16,000	94	18,800
2) Site Preparation	$ 75,000/acre	40	3,000	40	3,000	51	3,825	51	3,825	60	4,500	78	5,850	80	6,000	94	7,050
3) Paving																	
- asphalt	$125,000/acre	55	6,875	35	4,375	45	5,625	45	5,625	55	6,875	70	8,750	70	8,750	94	11,750
- crane pads	$ 25,000/1,000 sq	-	-	-	-	-	-	-	-	5	125	16	400	8	200	-	-
Total			6,875		4,375		5,625		5,625		7,000		9,150		8,950		11,750
4) Buildings																	
- offices	$250,000/$500,000	1	250	1	250	1	250	1	250	1	500	1	500	1	500	1	500
- garage	$100,000 each	1	100	1	100	1	100	1	100	1	100	1	100	1	100	1	100
- gate booths	$ 15,000 each	1	15	1	15	2	30	2	30	4	60	4	60	4	60	4	60
Total			365		365		380		380		660		660		660		660
5) Track and Ramps, etc.																	
- terminal	$ 75,000/1,000 ft.	17	1,275	13	975	13	975	17	1,275	15	1,125	34	2,550	26	1,950	26	1,950
- make-up tracks	$ 50,000/1,000 ft.	12	600	9	450	12	600	12	600	13	650	12	600	18	900	18	900
- switches	$ 18,000 each	25	450	21	378	22	396	25	450	22	396	35	630	20	720	20	720
- ramps	$ 3,000 each	10	30	5	15	-	-	-	-	-	-	-	-	-	-	-	-
Total			2,355		1,818		1,971		2,325		2,171		3,780		3,570		3,570

6) Improvements																	
- fencing	$ 15,000/1,000 ft.	7	105	6	90	6	90	6	90	7	105	2	120	8	120	11	165
- flood lights	$ 50,000 each	18	900	12	600	15	750	15	750	19	950	24	1,200	24	1,200	28	1,140
- weigh scales	$ 75,000 each	2	150	1	75	2	150	2	150	4	300	4	300	4	300	4	300
- hydro substation	$100,000 each	1	100	1	100	1	100	1	100	1	100	1	100	1	100	1	100
- banding/tarps	$100,000 each	1	100	1	100	1	100	1	100	1	100	1	100	1	100	1	100
- compressors	$ 15,000 each	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15
- fuel storage	$ 30,000 each	1	30	1	30	1	30	1	30	2	60	2	60	2	60	2	60
Total			1,400		1,010		1,235		1,235		1,630		1,895		1,895		2,140
7) Management Systems																	
- communications	$ 50,000 each	-	-	-	-	1	50	1	50	2	100	2	100	2	100	2	100
- computers	$175,000 each	-	-	-	-	1	175	1	175	2	350	2	350	2	350	2	350
Total							225		225		450		450		450		450
8) Handling Equipment																	
- light toplifters	$200,000 each	2	400	-	-	1	200	1	200	3	600	-	-	-	-	-	-
- toplifters	$450,000 each	5	2,250	4	1,800	9	4,050	9	4,050	6	2,700	6	2,700	5	2,250	12	5,400
- piggypackers	$550,000 each	1	550	-	-	3	1,650	3	1,650	4	2,200	-	-	4	2,200	4	2,200
- 030 cranes	$1,250,000 each	-	-	-	-	-	-	-	-	-	-	12	15,000	-	-	-	-
- 060 cranes	$2,000,000 each	-	-	-	-	-	-	-	-	9	18,000	-	-	8	16,000	-	-
Total			3,200		1,800		5,900		5,900		23,500		17,700		20,450		7,600
9) Underpass	$ 62,500 each *	-	-	-	-	-	-	-	-	1	63	-	-	-	-		-
10) Total			30,970		20,368		29,361		29,715		51,974		55,085		57,975		52,020
11) Weighted Average CVCOC Factor			0.19887		0.19790		0.19858		0.19813		0.19913		0.19865		0.20006		0.20027
12) Annual Capital Carrying Charge			6,159		4,031		5,831		5,888		10,350		10,943		11,599		10,418

(*) railway portion

3.2 Annual Terminal Operating Costs

The classification of the annual operating costs has been made in such a manner that each cost group is proportional to an easily identified parameter such as units handled, pieces of equipment employed, etc. The individual cost classifications are discussed below and the costs for each case are presented in Table 4.30.

3.2.1 Administration

These costs are predominantly the wages and salaries of the terminal management, the clerical functions and security. At the present terminal, this factor amounts to an annual cost of $1,200,000.

3.2.2 Machine Operators and Fuel

The cost of machine operators and the fuel consumed by their machines is directly proportional to the number of shifts worked. The 10 operators employed at the present terminal average $26,500 per annum.

3.2.3 Groundmen, Utilitymen, and Foremen

The cost of these individuals is a function of throughput volume. At the present terminal, this cost averages $2.00 per unit handled.

3.2.4 Equipment Repairs

The repair costs for the handling equipment averages 12 percent of the capital purchase prices shown in Section 8 of Table 4.29.

3.2.5 Miscellaneous Charges

These charges amount to 42 percent of the total terminal operating charges (excluding contracted hostling shuttling and pick-up and delivery). These charges are predominantly related to property and wages and cover such things as property taxes, snow removal, pavement and fencing repairs, salary and wage benefits, etc.

3.2.6 Hostling Tractor Costs

These services are provided by a contractor who charges on a unit basis. For the existing terminal operation, the equivalent of 3 morning shifts and 4 afternoon shifts are required for the average work day. The total contract price was $750,000 which averages $107,000 for the seven daily shifts. This average is applied to the shifts determined for each case in Section 2 and presented in Table 4.30.

3.2.7 Shuttling Costs

These services are provided by the hostling tractor contractor mentioned above and again average $107,000 per shift. These charges amount to approximately $320,000 annually at the present terminal for the 3 shifts used.

3.2.8 Annual Capital Carrying Charges

These charges have been extracted from Table 4.29.

3.2.9 Pick-up and Delivery and Highway Haul

These services are provided by another contractor and apply only to those units which require this service. At the present terminal, only 60 percent of the units handled required pick-up or delivery or highway haul at an average cost of $100 per unit handled.

3.2.10 Switching Charges

The average yard engine shifts required at the present terminal are 4 during the weekdays, 2 on Saturdays, and 1 on Sundays and holidays, a total of 23 shifts per week. At the Case A level of 100,000 units, a saving of one shift during weekdays should be realized which would reduce the total to 18 shifts per week.

As the volumes increase towards the 200,000 unit level in the B cases, the number of yard engine shifts should remain constant at 18 shifts per week because of the reduced numbers of tracks to be switched. The number of shifts should also remain constant up to the 400,000 unit level for Case C2 because the provision of run-through tracks will enable the arriving and departing locomotives to do more of the switching of their cars. Also, because the increase in traffic will occur using the same number of destination terminals, the amount of marshalling required will continue to be reduced as more solid destination tracks are loaded. For the C1 case, the number of shifts must be increased to 23 per week because of the high track turnover required.

For the C3 and C4 cases, the number of switching shifts required is again reduced to 13 per week. This reduction from the C1 and C2 cases results from the fact that the track turnover requirements are reduced to a factor of 2 because of the expanded size of the terminals.

Table 4.30 Annual Terminal Operating Costs - All Cases

Activity	Unit Cost	Present 150,000 Units		Case A 100,000 Units		Case B1 200,000 Units		Case B2 200,000 Units		Case C1 400,000 Units		Case C2 400,000 Units		Case C3 400,000 Units		Case C4 400,000 Units	
		U	$	U	$	U	$	U	$	U	$	U	$	U	$	U	$
1) Administration	(1)	-	1,200	-	1,000	-	1,200	-	1,200	-	1,380	-	1,380		1,380		1,380
2) Machine Operators and Fuel	$26,500 per operator (2)	10	265	7	186	19	494	19	494	31	775	29	725	25	625	22	550
3) Groundmen, Foremen, Utilitymen	$2.00 per unit handled	-	300	-	200	-	400	-	400	-	800	-	800	-	800	-	800
4) Equipment Repairs	12% of 8 in Table 4.29 (5)	-	384	-	216	-	708	-	708	-	2,060	-	1,824	-	1,794	-	912
Subtotal			2,149		1,602		2,802		2,802		5,015		4,729		4,599		3,642
5) Miscellaneous Charges	42% of Subtotal	-	903	-	673	-	1,177	-	1,177	-	2,106	-	1,986	-	1,932	-	1,530
6) Hostling Costs	$107,000 (3) per driver	7	749	5	535	7	742	8	848	15	1,575	18	1,890	13	1,365	13	1,365
7) Shuttling Costs	$107,000 (3) per driver	3	321	-	-	-	-	-	-	5	525	20	2,100	-	-	-	-

8) Annual Capital Carrying Charges	See Table 4.29	-	6,159	-	4,031	-	5,831	-	5,888	-	10,350	-	10,943	-	11,599	-	10,418
Total Terminal Operating Costs			10,281		6,841		10,552		10,715		19,571		21,648		19,495		16,955
Total Terminal Operating Costs Per Unit			$68.54		$68.41		$52.76		$53.58		$48.93		$54.12		$48.74		$42.39
9) Pick-up and Delivery; Highway Haul	$100 per unit handled (4)	-	9,000	-	6,000	-	11,760	-	11,760	-	23,280	-	23,280	-	23,280	-	23,280
10) Switching Charges	$90,000 per weekly shift	23	2,070	8	1,620	18	1,620	8	1,620	3	2,070	8	1,620	3	1,170	3	1,170
Total Beyond Rail Haul Costs			21,351		14,461		23,932		24,095		44,921		46,548		43,945		41,405
Total Beyond Rail Haul Costs per Unit			$142.34		$144.61		$119.66		$120.48		$112.30		$116.37		$109.86		$103.51

(1) See Section 5.7, Appendix II.

(2) See Section 5.7, Appendix II. The unit cost reduces to $26,000 per machine and $25,000 per machine for the B and C cases respectively.

(3) See Section 5.7, Appendix II. The unit cost reduces to $106,000 per driver and $105,000 per driver for the B and C cases respectively.

(4) See Section 5.7, Appendix II. The unit cost reduces to $98 per unit and $97 per unit for the B and C cases respectively.

(5) 030 cranes assumed to be 10 percent of capital cost and 060 cranes 7 percent.

4. CONCLUSIONS

The general conclusions reached as a result of the preceeding sections on terminal configurations, operating concepts, and handling equipment are as follows:

a) integral terminals with storage in the working area are more economical than transfer terminals with storage in remote locations because the integral terminal is more efficient in terms of space requirements and less on-site hostling is required.

b) for handling trailers, piggypackers are more efficient than hostlers operating on circus loading ramps; however, they cannot really be justified until an annual throughput of approximately 70,000 trailers is attained. This statement is based upon the assumption that a minimum of 2 machines are required to guard against breakdowns. Some terminals operate with one unit only and the terminal stops operating when breakdowns occur.

c) 060 cranes for handling marine containers and which permit storage under the span cannot be justified until the cost of land (including preparation and paving) exceeds a minimum of $1,000,000 per acre; otherwise toplifters are more economical.

d) cranes for handling trailers do not appear to be economically viable.

Generally speaking, therefore, the most effective layouts for high volume terminals are as follows:

- trailers handled by piggypackers and utilizing 2 centre storage aisles;
- domestic containers handled by toplifters and utilizing 2 centre storage aisles for containers on chassis or empty chassis, or 8 rows of empty containers stored 4 high;
- marine containers handled by 060 cranes (assuming very expensive real estate values) and utilizing a 2-3-3-2 high storage configuration for loaded containers and a 4-4-4-4 configuration for empty containers. For less expensive land values, toplifters storing loaded marine containers in 2 X 2 piles and empty containers in 3 or 4 X 4 high piles are more economical.

These conclusions are developed in more detail in the following sections.

4.1 Terminal Operating Philosophy

The decision as to whether to operate an integral terminal (with storage within the working area) or a transfer terminal (with storage in a remote location) is easily made after reviewing the relative space efficiencies of the layouts presented in Annex 4.2. In all cases, the integral terminals are more space efficient and require less hostling. Furthermore, a comparison of the costs for the expansion cases B1, B2, C1, and C2 as presented in Table 4.30 also shows that the integral cases (B1 and C1) are more economical than the transfer cases (B2 and C2). For the ideal Terminal 'X', therefore, the integral concept has been used.

Circus loading ramps are not space efficient and require a high degree of hostling and are recommended only for small volume, low capital cost installations.

4.2 The Introduction of Piggypackers

Because of the high capital cost of piggypackers, they should be introduced only when they can be utilized fully. It is unwise to base an operation on only one machine because a failure can effectively shut down the operation. The minimum investment should be, therefore, 2 machines so that the terminal may still operate on an emergency basis in the event that one machine goes down for maintenance reasons. The basic machine requirements as defined in Section 2 are as follows:

$$\frac{2.0 \text{ piggypackers}}{1.20 \text{ for repairs}} = 1.67 \text{ basic machines}$$

The translation of this requirement into the annual throughput required or threshold volume is based upon the unloading requirements and is determined as follows:

$$\begin{aligned} & 1.67 \text{ piggypackers} \times 72 \text{ peak period handlings (Table 4.4)} \\ &= 120 \text{ peak period units} \div 0.90 \text{ (Table 4.3)} \\ &= 134 \text{ peak day units} \div \frac{1{,}889}{10{,}000} \text{ (Table 4.5)} \\ &= 70937 \text{ annual handlings of trailers.} \end{aligned}$$

For an operation like Terminal 'X' with one-third each for trailers, Domestic Containers and marine containers, the threshold volume for the acquisition of piggypackers is approximately 210,000 units per year. For terminals handling only trailers and marine containers, (i.e. no Domestic Containers), the threshold volume reduces to approximately 110,000 units per year. These limits are theoretical, however, and assume that there is enough space in the terminal to operate an integral terminal without hostling to a remote on-site storage area or shuttling to a remote off-site location.

In the case of the present Terminal 'X', these throughput threshold volumes are much lower because the shortage of space at the main terminal forces the terminal manager to shuttle containers to the empty annex (remote off-site location). In this instance, it is better to remove the circus loading ramps at a smaller annual volume than determined above and to tolerate some under-utilization of the piggypackers in exchange for saving the shuttling costs.

In order to determine the breakeven or threshold volume at which the circus ramps should be removed for the existing Terminal 'X', the annual operating costs for Case B1 have been calculated at the existing throughput levels of 150,000 units per year. The interpolation of the present costs between the costs for Case A at 100,000 units and the recalculated Case B1 at 150,000 units gives the approximate threshold volume. Table 4.31 below recalculates the basic handling equipment requirements for Case B1 (see Table 4.11) at the 150,000 unit level.

Table 4.31 Basic Handling Equipment Requirements - Case B1 Configuration at 150,000 Units Per Year

Activity	Annual Volume (units)	Handling Factor (per 10,000 units)	Peak Day Units	Units Per Machine	Machines Required
Unloading					
- trailers	50,000	1.889	94	72	1.3 packers
- domestics	50,000	1.500	75	51	1.5 toplifters
- marines	50,000	2.651	133	55	2.4 toplifters
Loading					
- trailers	50,000	2.675	134	120	1.1 packers
- domestics	50,000	2.227	111	90	1.2 toplifters
- marines	50,000	1.750	88	96	0.9 toplifters

In addition to these basic requirements, the following additional machines are required:

- one toplifter for handling loaded marine containers in the remote area along the north property line;
- one toplifter for handling the empty marine storage area.

The total machinery requirements including 20 percent for maintenance are, therefore, 2 piggypackers and 5 toplifters (including one light model) for the peak loading period and 2 piggypackers and 7 toplifters (including one light model) for the peak unloading period. Two piggypackers are required to ensure continuous service as discussed previously. Fourteen machine operators are required.

The hostling tractor requirements are calculated as before in Table 4.12 as follows:

Table 4.32 Hostling Tractors Required - Case B1 Configuration At 150,000 Units Per year

Activity	Peak Period units	Peak Hours units	Working Area		Remote Area		Weighted Average Rate	Tractors Required
			Handling Rate	Unit Storage	Handling Rate	Unit Storage		
Unloading								
- trailers	85	28	30.0	230	20.0	0	30.0	0.93
- domestics	68	23	20.0	263	11.4	0	20.0	1.15
								2.08
Loading								
- trailers	101	20	30.0	230	20.0	0	30.0	0.67
- domestics	83	16	16.0	263	11.4	0	16.0	1.00
								1.67

An additional 25 percent is added to these figures in order to account for delays. The number of tractors required is, therefore, 3 tractors for the peak unloading periods and 3 tractors for the peak loading periods. Six tractor drivers are required.

The capital costs developed previously in Table 4.28 must be recalculated to reflect the reduction in handling equipment required as determined in Table 4.30. The handling equipment investment becomes :

1 light toplifter @ $200,000 each = $ 200,000
6 toplifters @ $450,000 each = $2,700,000
2 piggypackers @ $550,000 each = $1,100,000
$4,000,000

The total investment becomes $27,461,000 and the annual capital carrying charge $5,452,000.

The annual operating costs as developed previously in Table 4.30 become as follows:

Table 4.33 Annual Operating Costs - Present Terminal 'X' Versus Case B1 At 150,000 Units (in $1,000)

Activity	Unit Cost	Present Circus Loading		Case B1 Piggypacker Operation	
		U	$	U	$
1) Administration		-	1,200	-	1,200
2) Machine Operators and Fuel	$26,500 per operator	10	265	14	371
3) Groundmen, Foremen, Utilitymen	$2.00 per unit handled	-	300	-	300
4) Equipment Repairs Subtotal	12% of 8 in Table 4.29	-	384	-	480
5) Miscellaneous Charges	42% of Subtotal	-	903	-	987
6) Hostling Costs	$107,000 per driver	7	749	6	642
7) Shuttling Costs	$107,000 per driver	3	321	-	-
8) Annual Capital Carrying Costs	See Table 4.29	-	6,159	-	5,452
9) Pick-Up and Delivery; Highway Haul	$100.00 per unit handled	-	9,000	-	9,000
10) Switching Charges	$90,000./ weekly shift	23	2,070	18	1,620
Total			21,351		20,052
Total Per Unit			$142.34		$133.68

Since the Case A average cost per unit was $144.61, the threshold volume for this terminal appears to be approximately 110,000 units per year. At this volume, the annual operating costs for the piggypacker and circus loading cases are approximately identical.

4.3 The Introduction of 060 Cranes for Marine Containers

The most space efficient layouts for toplifters handling containers in integral terminals are shown in Annex 4.3.3 and 4.3.4. The most space efficient layout for 060 cranes handling marine container is also shown in these annexex. Although the 060 cranes are more space efficient, the higher capital costs and slower handling capabilities mean that the 060 cranes should be installed only where land value is high enough to withstand these drawbacks.

The equipment requirements of the C cases are used for this analysis of threshold land values. At the 400,000-unit level, 7.92-060 cranes (6.6 plus 20 percent for maintenance) or 6.94 toplifters (5.78 plus 20 percent for repairs) are required and the storage requirements are 2,133 TEU for loaded containers and 2,267 TEU for empty containers. The threshold land value is determined by equating the cost of land, equipment (including repair costs) and operators and fuel for the two cases being considered. The areas required for the toplifter case (assuming high density 4 X 4 storage piles for empties and 2 X 2 piles for loads) and the 060 crane case are as follows:

. Toplifters - loads = 2,133 TEU X 435.5 sq.ft./TEU
= 928,922 sq.ft = 21.33 acres
- empties = 2,267 TEU X 133.1 sq.ft./TEU
= 301,738 sq.ft = 6.93 acres
28.26 acres

. 060 Cranes - loads = 2,133 TEU X 185.0 sq.ft./TEU
= 394,605 sq.f.t = 9.06 acres
- empties = 2,267 TEU X 115.6 sq.ft./TEU
= 262,065 sq.ft. = 6.02 acres
15.08 acres

The storage area requirements per TEU have been extracted from the data in annex 4.3.

The equations for terminating the annual operating costs uses the CVCOC factors for land and equipment presented in Table 4.28 as follows:

. Toplifter costs = 28.26a (0.18383) + 6.94 ($450,000)(0.19929)
+ 0.12 (6.94)($450,000) + 5.78 ($25,000)

= 5.195a + $1,141,643

. 060 Crane costs = 15.08a (0.18383) + 7.92 ($2,000,000)(0.19929)
+ 0.07 (7.92)($2,000,000) + 6.60 ($25,000)

= 2.772a + $4,430,554

Equating these 2 equations allows a, the threshold land value, to be determined as follows:

$$5.195a + \$1,141,643 = 2.772a + \$4,430,554$$
$$a = \$1,357,371 \text{ per acre}$$

This value is far higher than the present value of land at Terminal 'X' of $400,000 per acre including site preparation, paving, fencing, floodlights, etc. Even if 3 X 3 storage piles are handled by toplifters (215.1 sq.ft./TEU), the threshold land value still remains high at $1,025,541 per acre. As such, any new facility built near Terminal 'X' should use toplifters. This statement can be verified by comparing the terminal operating costs for the C3 and C4 cases in Table 4.30.

4.4 The Introduction of 030 Cranes for Trailers

An analysis similar to the one made in Section 4.3 can be made for 030 cranes handling trailers versus piggypackers handling trailers. The same 2 centre aisle storage arrangements are considered - see Annexes 4.2.8 and 4.2.14. In this example, there is no space advantage to the use of 030 cranes; in fact, there is a slight penalty, 1,719 sq.ft. per trailer for 030 cranes and 1,413 sq.ft. per trailer for piggypackers. Since 030 cranes cost considerably more than piggypackers ($1,750,000 versus $550,000) and because there are no handling improvements available by using them (see Table 4.4), there is no economic justification for using 030 cranes for integral terminals. The use of 030 cranes may provide some advantage in specialized applications such as "sprint" operations or in transfer terminals where the narrow width of the property precludes the establishment of integral terminals. These cases must be evaluated on their own merits.

4.5 The Introduction of 060 Cranes for Trailers

This operation may be feasible in locations where land is scarce and real estate values are high. Trailers could be stored parallel to the tracks under the crane span and would have to be selectively retrieved for delivery or loading onto rail cars (in other words treated like containers). Eight trailers could be stored under the crane span in a 100-foot section of 2-track module (8,600 square feet) and the resulting space requirements would be 1,075 square feet per trailer. Because most of the trailers would require 2 cycles to be handled, the same 50 percent reduction from cycles to handlings that was made for marine containers handled by cranes must be used and an average handling rate of 48 trailers per peak unloading period results (see Table 4.4).

The following equipment and space requirements result for the Case C volumes.

- Piggypackers required (excluding the 20 percent for repairs)
  227 peak period units ÷ 72 = 3.15 packers (Table 4.16)
- 060 cranes required (excluding the 20 percent for repairs)
  227 peak period units ÷ 48 = 4.73 cranes

- Piggypacker operators required - 7
- 060 crane operators required - 9

- Land for piggypacker operation - 613 trailers X 1,413 sq.ft/trailer
  = 866,169 sq.ft. = 19.88 acres

- Land for 060 crane operation = 613 trailers X 1,075 sq.ft./trailer
  = 658,975 sq.ft. = 15.13 acres

The threshold land value a is determined by equating the annual cost of land, equipment, operators, fuel, and repairs as was done in Section 4.3.

- Piggypackers costs = 19.88a (0.18383) + 3.15 (1.20)($550,000)(0.19929)
  + 7 ($25,000) + 3.15 (1.20)(0.12)($550,000)
  = 3.655a + $838,804

- 060 crane costs = 15.13a (0.18383) + 4.73 (1.20)($2,000,000)(0.19929)
  + 9 ($25,000)) + 4.73 (1.20)(0.07)($2,000,000)
  = 2.781a + $3,281,980

3.655a + $838,804 = 2.781a + $3,281,980
a = $2,795,396 per acre

Again, because the threshold land value needed to justify the installation of 060 cranes is so high, it is not surprising that they are seen mainly in the industrial centres of very large cities and in busy harbours where land values can justify the high capital costs. The use of 060 cranes for trailers, however, cannot be justified.

4.6 General Observations

The cases studied in this report have shown that an almost infinite number of combinations can be studied. Every change in these factors also affects shuttling, hostling, and switching costs for the same terminal location. For this reason, it it is not possible to produce a generalized model of the "ideal" intermodal terminal.

For any given terminal layout, manual simulation techniques seem to offer a low cost method of determining the capacities and bottlenecks for any configuration and number of pieces and types of equipment. The peak day and peak hour traffic patterns should be determined for each terminal being studied as was done in Appendix I since the arrival and departure patterns at each terminal may vary.

The cost calculations have produced the following recommendations for the specific traffic mix and volumes being handled by Terminal 'X'.

- the existing circus loading ramps should be replaced with a piggypacker operation as soon as the capital is available.
- the use of toplifters for marine containers should be continued because 060 cranes are too expensive for present land values.

These 2 recommendations correspond roughly to Case B1 (see Figure 4.3). These changes will reduce operating costs significantly and will increase the ability of the terminal and the existing empty annex to handle volume increases up to at least 225,000 units per year. Beyond this level, either a new site should be considered based upon Case C4 or a split terminal operation should be inaugurated.

Before any terminal changes are contemplated, however, simulations should be run again with the new equipment, trackage, and volumes anticipated in order to confirm the capacity of the terminal and to identify any unforeseen bottlenecks or constraints. Also, the simulation exercise should be expanded to include the terminal, make-up and yard tracks to check on the ability of the switch engines and road units to handle the new tonnage in what will probably be more single and double destination trains.

Annex 4.1 Terminal Design Parameters for Trailers

Annex 4.1.1 Trailer Parking Space Requirements

(allowing 2 feet of separation between trailers)

Longitudinal Angle Between Track and Trailer	Trailer Pitch (feet)	Trailer Depth (feet)	Units per 100 feet of Track Length	Depth of Traffic Lane Required for Maneuvering (feet)
90 degrees	10.5	45	9	60
68 degrees	12	45	8	56
50 degrees	14	40	7	46
40 degrees	16	35	6	39
30 degrees	20	30	5	30
15 degrees	50	20	2	16
0 degrees	65	10.5	1.5	15

Note: The depth of the traffic lane could be reduced by parking trailers further apart.

Annex 4.1.2 Track Layout and Rail Car Parameters

- Flat car deck width are assumed to be 10'0".
- Track centres for toplifter, piggypacker or crane operating are assumed to be 16'0" in order to allow room for the mechanical inspection of running gear by railway employees in small electric vehicles.
- Track centres for piggyback ramp operations are assumed to be either 16'0" to allow for the installation of catwalks or 13'0" to allow for manual inspections by railway employees on foot. These track centres will alternate.

For alternatives involving the use of piggypackers or cranes;

- The direction of travel (i.e. location of the trailer hitches on flat cars) is assumed to be random and not unidirectional as used to be the case when only piggyback ramps were used.

Annex 4.1.3 Handling Equipment Parameters

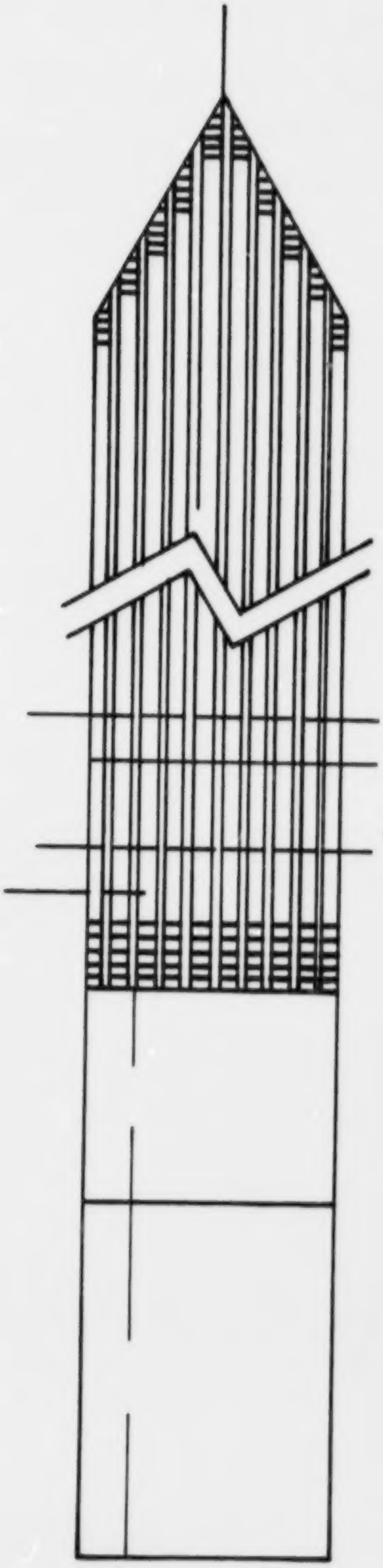
Piggypackers are assumed to be able to maneuver a 45-foot trailer from a rail car and place it into a storage pile 55 feet from the side of a rail car.

- Cranes require a 5-foot wide concrete pad for travelling.

Annex 4.2 Index to Standard Trailer and Equipment Layouts Using Existing Railroad Technology

4.2.1	Circus Loading Ramp - Long Tracks	(10 tracks)
4.2.2	Circus Loading Ramp - Short Tracks	(12 tracks)
4.2.3	"Sprint" - Piggypacker or Crane Without Centre Aisle Storage	(2 tracks)
4.2.4	Piggypacker Without Centre Aisle Storage	(2 tracks)
4.2.5	Piggypacker With Trackside and Centre Aisle Storage	(2 tracks)
4.2.6	Piggypacker With Trackside and Centre Aisle Storage	(2 tracks)
4.2.7	Piggypacker with Centre Aisle Storage	(2 tracks)
4.2.8	Piggypacker With 2 Centre Storage Aisles	(2 tracks)
4.2.9	020 Crane Without Centre Aisle Storage	(2 tracks)
4.2.10	020 Crane With Centre Aisle Storage	(2 tracks)
4.2.11	020 Crane With 2 Centre Storage Aisles	(2 tracks)
4.2.12	030 Crane Without Centre Aisle Storage	(4 tracks)
4.2.13	030 Crane With Centre Aisle Storage	(4 tracks)
4.2.14	030 Crane With 2 Centre Storage Aisles	(4 tracks)
4.2.15	Summary	

Appendix 4.2.1
Circus Loading Ramp
Long Tracks



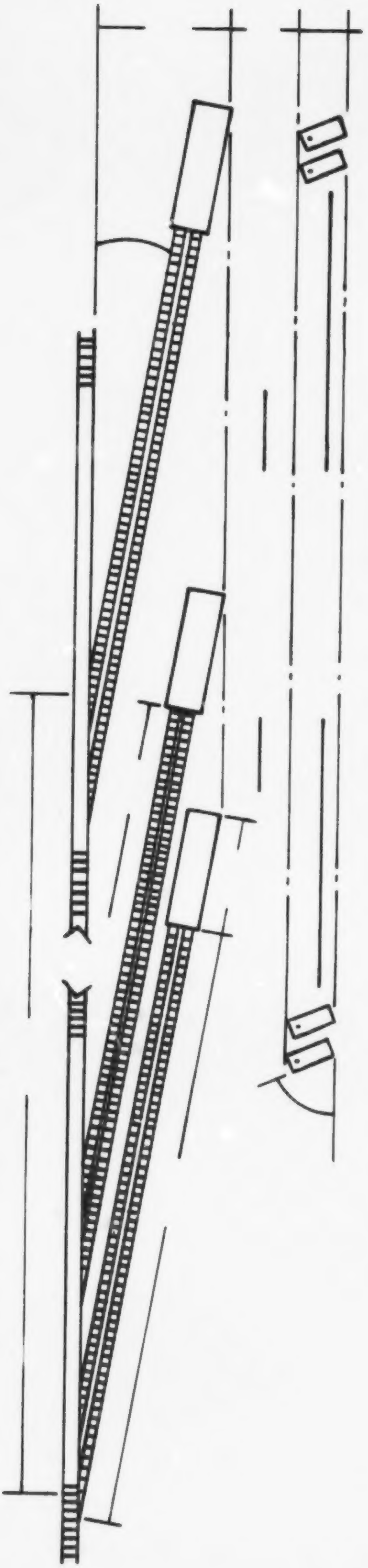
Circus Loading Ramp — 10 Long Tracks

For layout shown

- 10 ramp tracks; 10,538 feet of track; 183-57 foot 7 inch piggyback flat cars
- track area, plus ramp area, plus load drop area requires 225,500 square feet of yard space

For every 4 track slots

- 0 trackside slots
- 0 centre aisle slots
- 5,000 square feet in the working area



Appendix 4.2.2
Circus Loading Ramp
Short Tracks

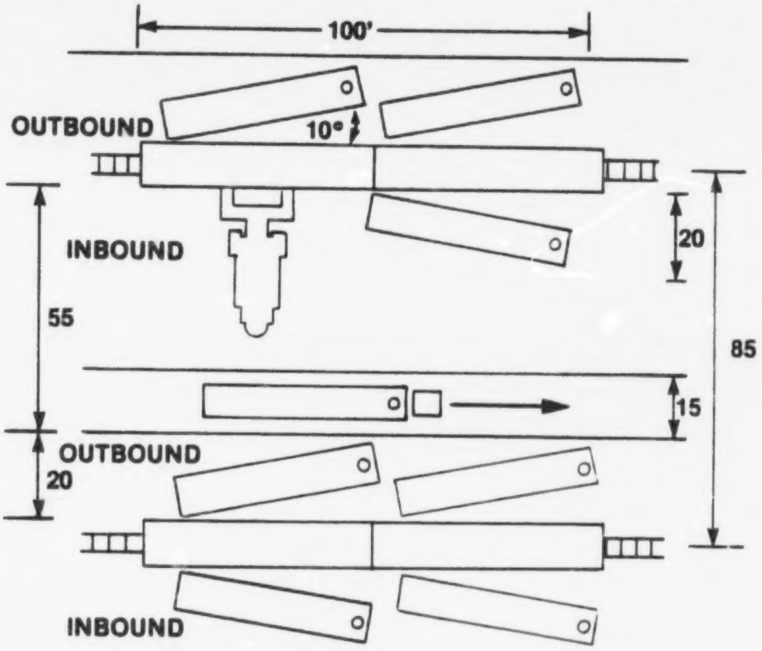
Circus Loading Ramp — 12 Short Tracks

For layout shown
- 12 ramp tracks; 6,600 feet of track; 114-57 foot 7 inch piggyback flat cars
- track area, plus ramp area, plus load drop area requires 171,000 square feet of yard space

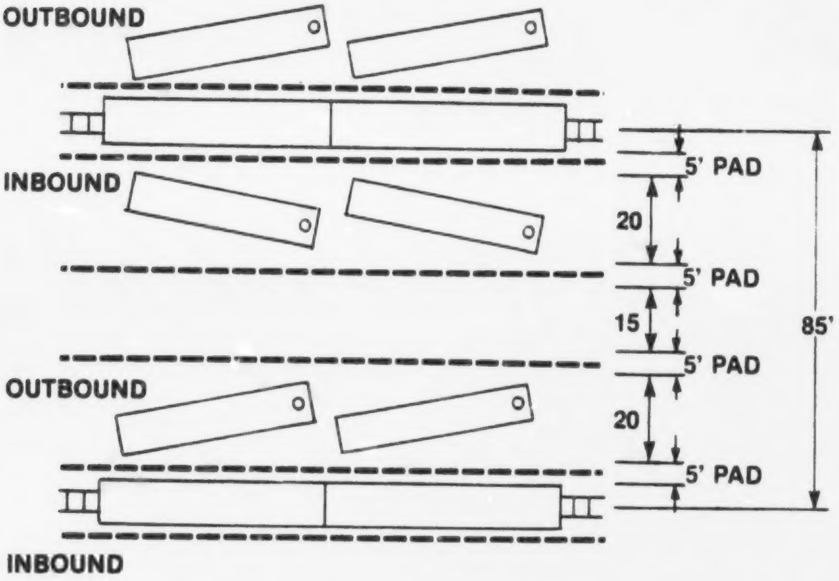
For every 4 track slots
- 0 trackside slots
- 0 centre aisle slots
- 6,000 square feet in the working area

Appendix 4-2-3
"Sprint" — Packer or Crane — 2 Track Module (Without Centre Aisle Storage)

1. **Packer**


100'
OUTBOUND
10°
INBOUND
55
20
85
15
OUTBOUND
20
INBOUND

2. **Crane**


OUTBOUND
INBOUND
5' PAD
20
5' PAD
15
5' PAD
85'
OUTBOUND
20
5' PAD
INBOUND

"Sprint" — Piggypacker or Crane Without Centre Aisle Storage

For every 100-foot section of the 2-track module:

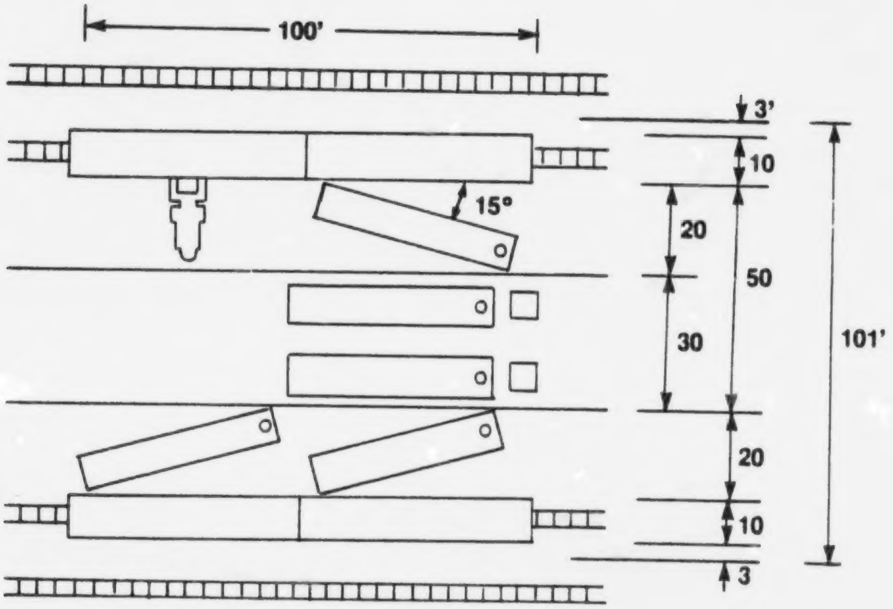
- 4 track slots
- 8 trackside slots   17,000 square feet in the working area
- 0 centre aisle slots

Note 1: The crane span is approximately 40 feet.

Note 2: This layout shows a "sprint" terminal with inbound and outbound parking on either side of the tracks.

Note 3: The "preloading" of chasses (adjacent to the inbound domestic containers) is only feasible with the crane arrangement.

Appendix 4-2-4
Packer — 2 Track Module (Without Centre Aisle Storage)



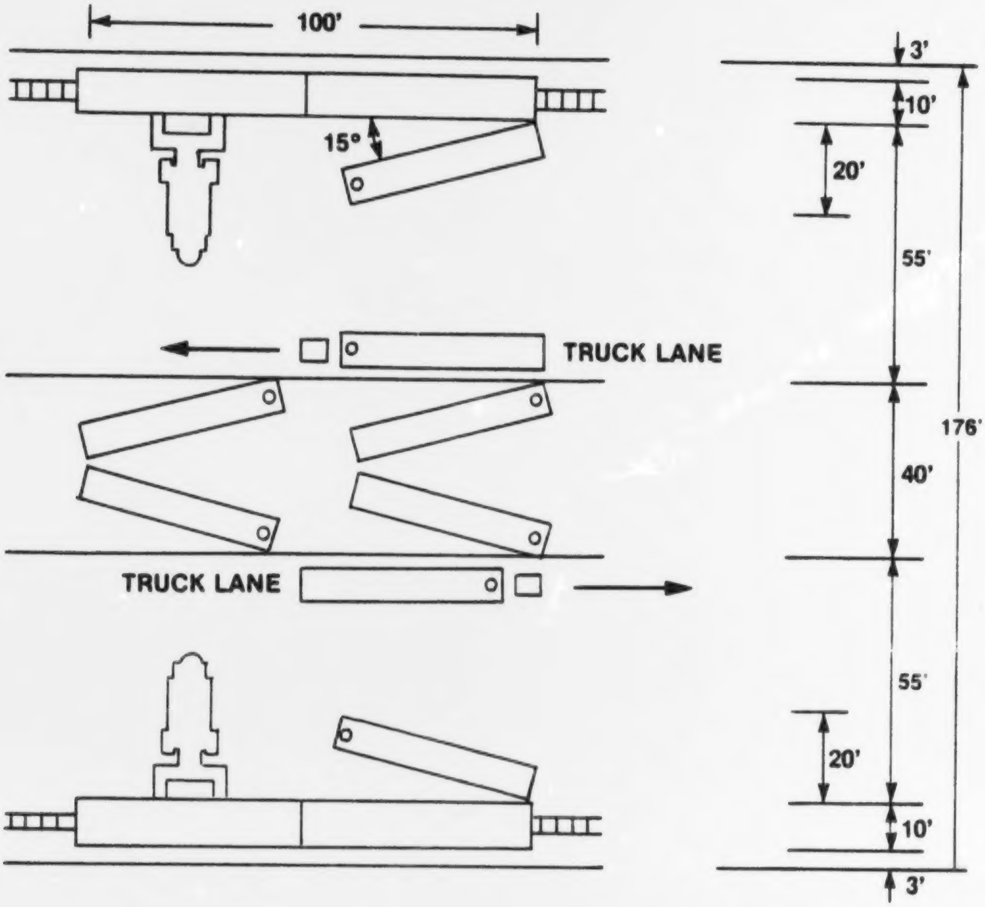
Piggypacker Without Centre Aisle Storage

For every 100-foot section of the 2-track module:

- 4 track slots
- 4 trackside slots — 10,100 square feet in the working area
- 0 centre aisle slots

Note 1: This layout shows a "transfer" terminal with hostling to remote storage.

Appendix 4-2-5
Packer — 2 Track Modules
(With Trackside and Centre Aisle Storage)



Piggypacker With Centre Aisle Storage

Hostler does NOT load the centre aisle.

For every 100-foot section of the 2-track module:

- 4 track slots
- 4 trackside slots
- 4 centre aisle slots

17,600 square feet in the working area

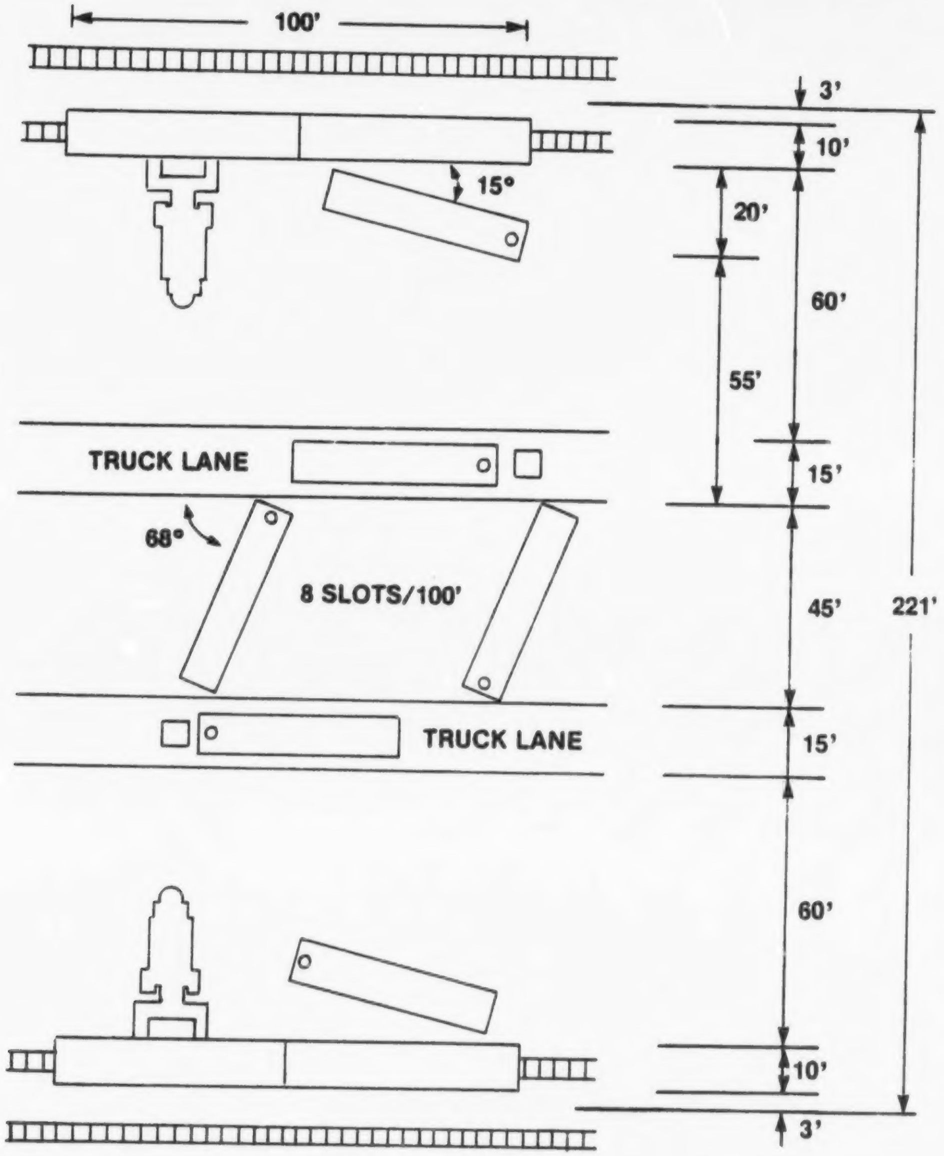
Note 1: This layout shows a "transfer" terminal with hostling to remote storage.

Note 2: The piggypacker would unload the trailers and place them directly into the central storage aisles *without* requiring a yard hostling tractor.

Note 3: This layout may possibly be suited to domestic container operations.

Appendix 4-2-6

Packer — 2 Track Module (With Trackside and Centre Aisle Storage)



100'
15°
TRUCK LANE
68°
8 SLOTS/100'
TRUCK LANE
3'
10'
20'
60'
55'
15'
45'
221'
15'
60'
10'
3'

Piggyparker With Trackside and Centre Aisle Storage

For every 100-foot section of 2-track module:

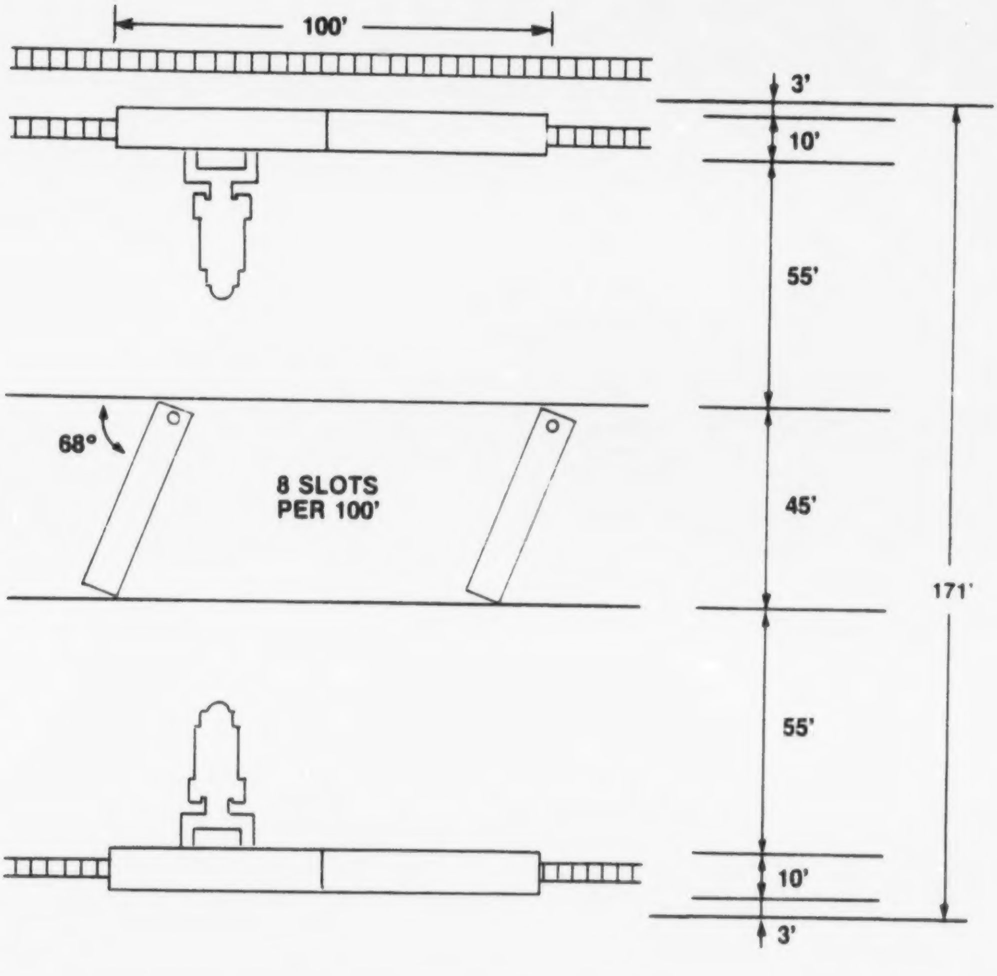
- 4 track slots
- 4 trackside slots
- 8 centre aisle slots

22,100 square feet in the working area

Note 1: The centre aisle storage areas would be loaded by road tractors.

Appendix 4-2-7

Packer — 2 Track Module (With Centre Aisle Storage)


100'
3'
10'
55'
68°
8 SLOTS
PER 100'
45'
171'
55'
10'
3'

Piggyparker With Trackside and Centre Aisle Storage

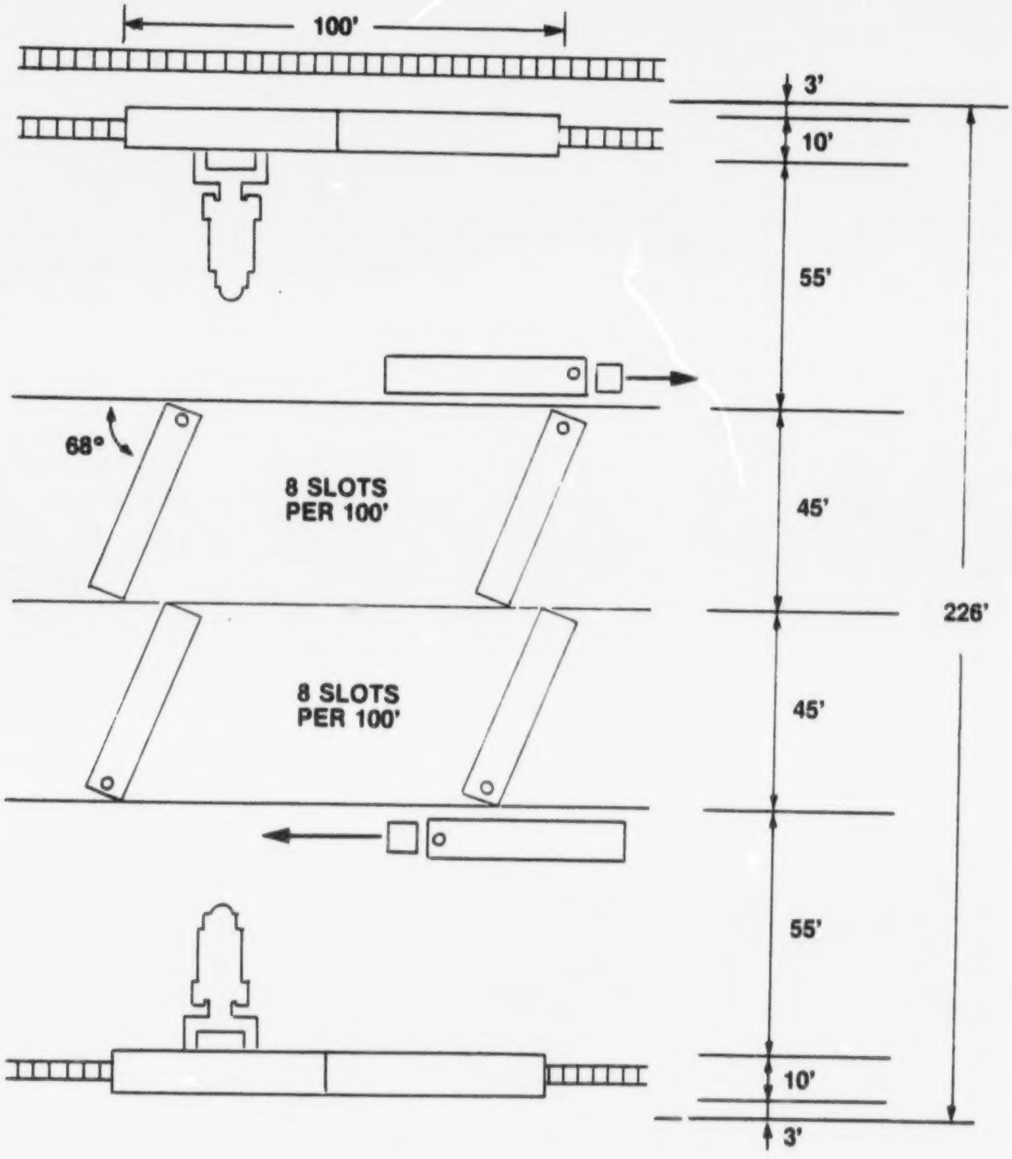
For every 100-foot section of 2-track module:

- 4 track slots
- 0 trackside slots
- 8 centre aisle slots

17,100 square feet in the working area

Note 1: The centre aisle storage areas would be loaded by road tractors.

Appendix 4-2-8
Packer — 2 Track Module
(With 2 Centre Storage Aisles)


100'
3'
10'
55'
68°
8 SLOTS
PER 100'
45'
8 SLOTS
PER 100'
45'
226'
55'
10'
3'

Piggypacker With 2 Centre Storage Aisles

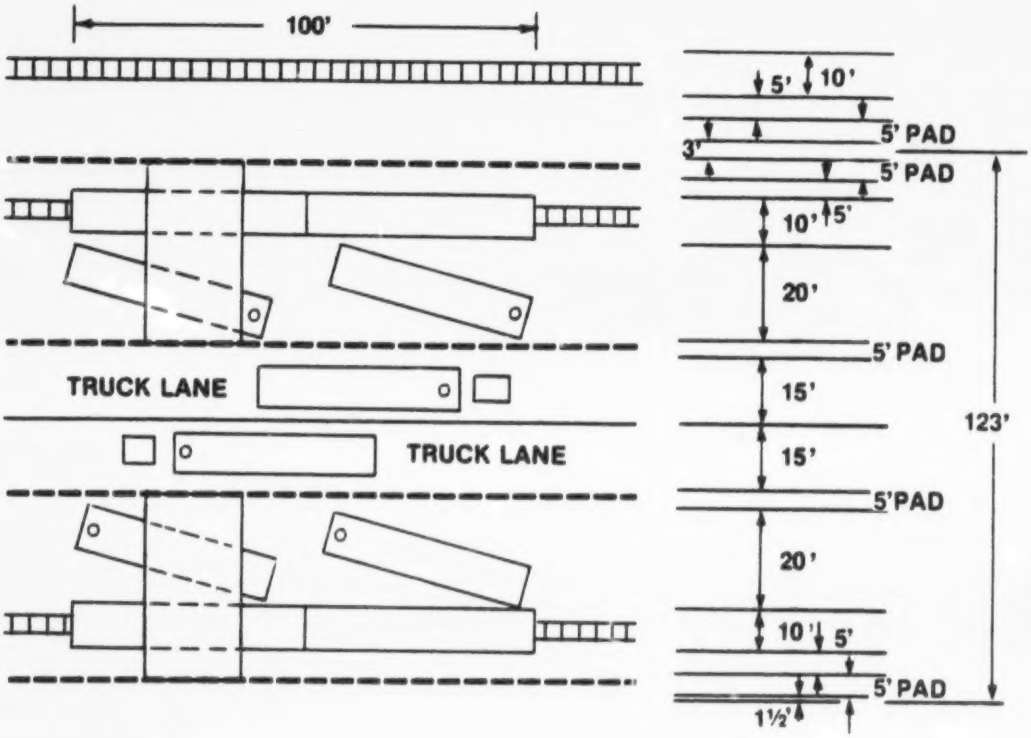
For every 100-foot section of 2 track module:

- 4 track slots
- 0 trackside slots

22,600 square feet required in the working area

- 16 centre aisle slots

Appendix 4-2-9
020 Crane — 2 Track Module
(Without Centre Aisle Storage)


100'
5'
10'
5' PAD
3'
5' PAD
10'
5'
20'
5' PAD
TRUCK LANE
15'
123'
15'
TRUCK LANE
5'PAD
20'
10'
5'
5' PAD
1½'

020 Crane Without Centre Aisle Storage

For every 100-foot section of 2-track module:

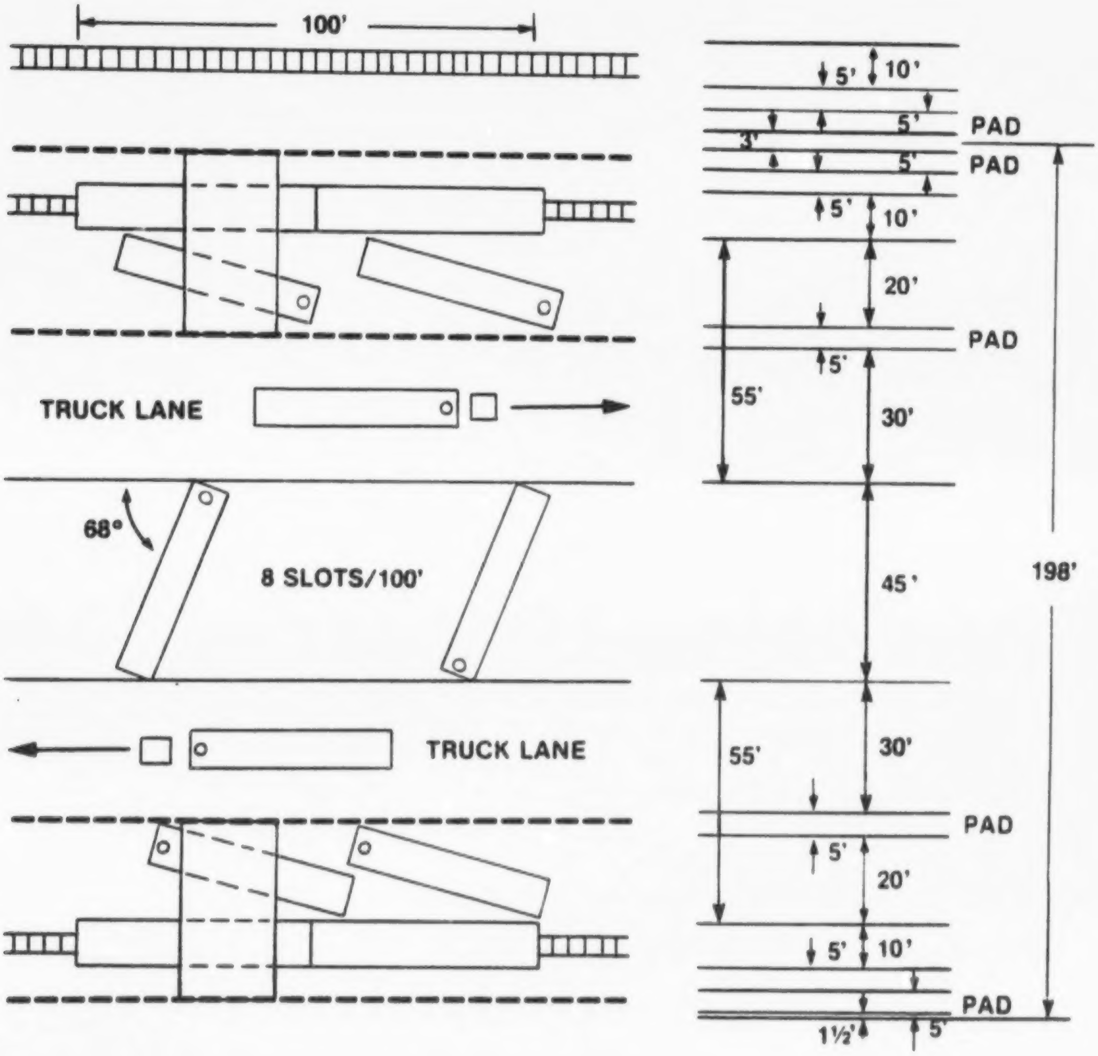
- 4 track slots
- 4 trackside slots 12,300 square feet in the working area
- 0 centre aisle slots

Note 1: Two trailers could be parked parallel to trackside instead of one trailer parked diagonally, however, the crane would have to re-handle the rail-side trailer for movement by the hostling tractor.

Note 2: The crane span is approximately 40 feet.

Note 3: This layout shows a "transfer" terminal with hostling to remote storage.

Appendix 4-2-10
020 Crane — 2 Track Module
(With Centre Aisle Storage)


100'
TRUCK LANE
68°
8 SLOTS/100'
TRUCK LANE
5'
10'
PAD
3'
5'
PAD
5'
10'
20'
PAD
5'
55'
30'
45'
198'
30'
55'
PAD
5'
20'
5'
10'
PAD
1½'
5'

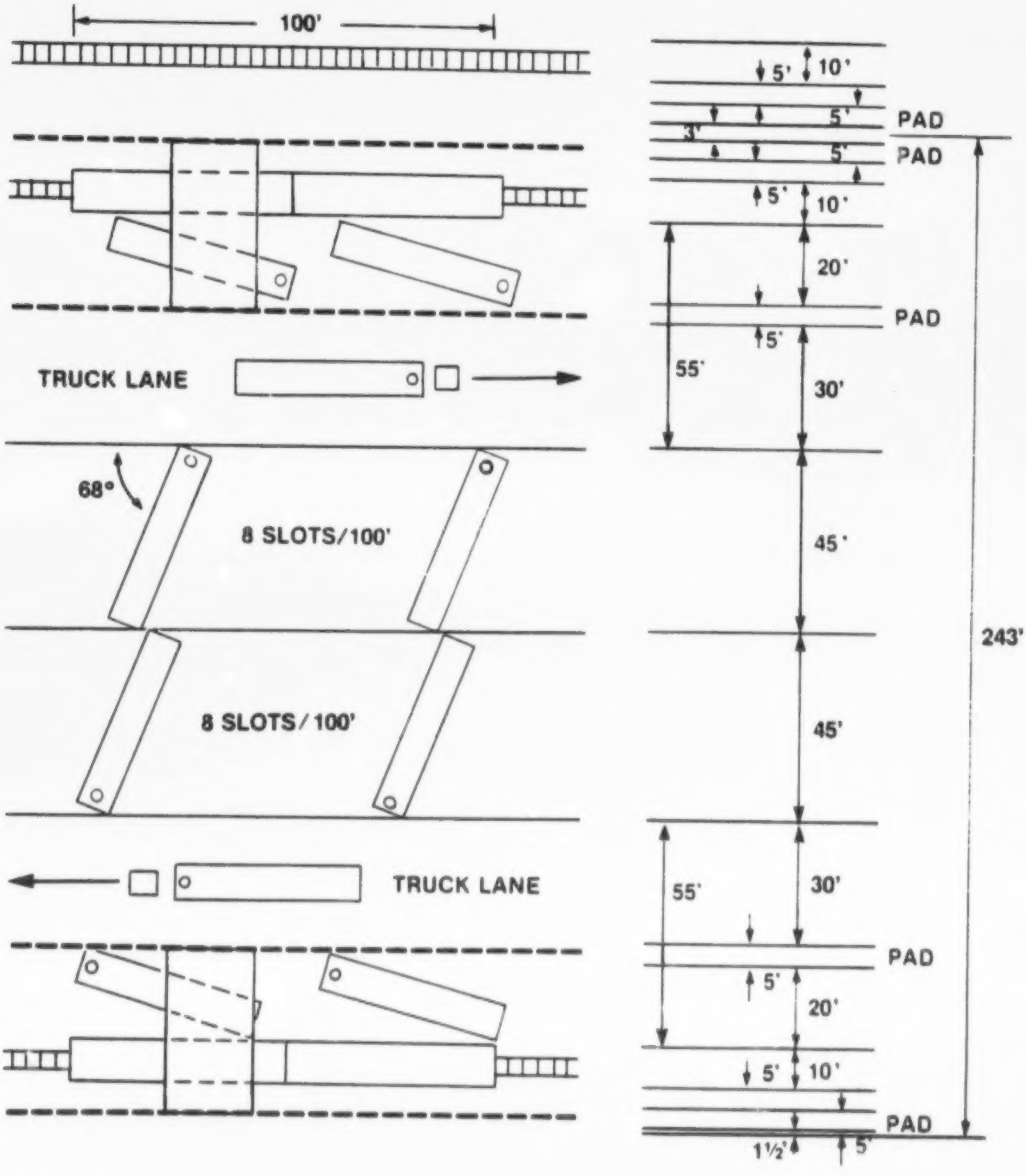
020 Crane With Centre Aisle Storage

For every 100-foot section of 2-track module:

- 4 track slots
- 0 trackside slots 19,800 square feet in the working area
- 8 centre aisle slots

Note 1: The crane span is approximately 35 feet.

Appendix 4-2-11
020 Crane — 2 Track Module
(With 2 Centre Storage Aisles)

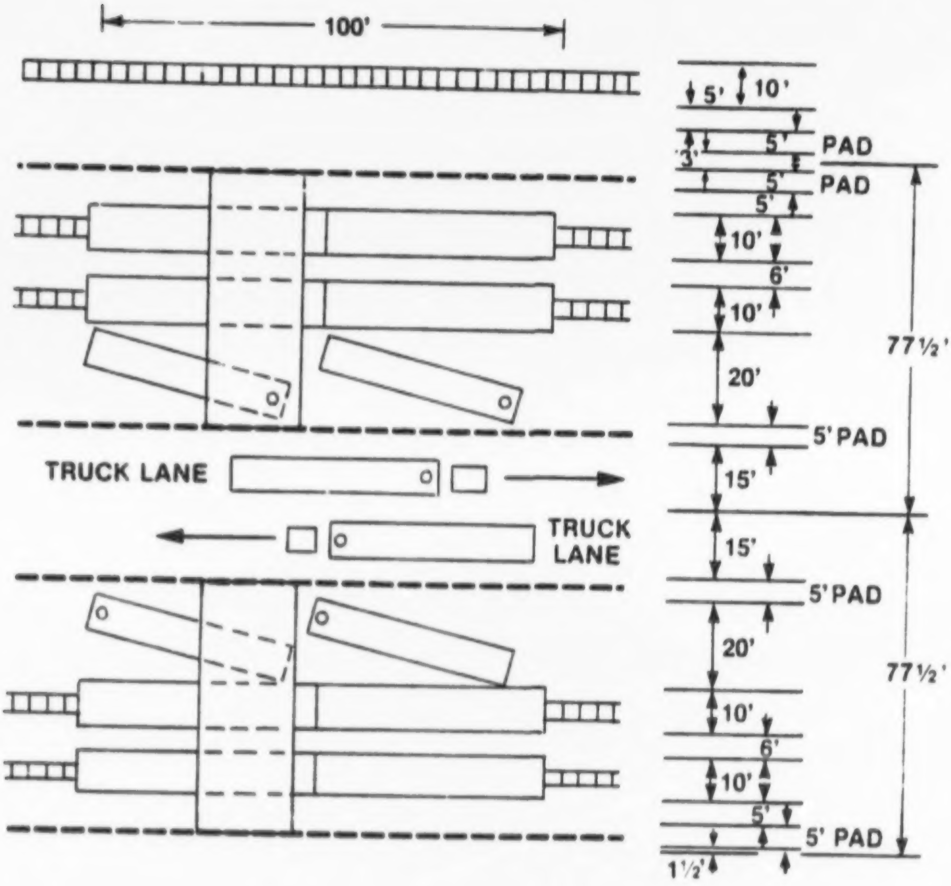

100'
TRUCK LANE
68°
8 SLOTS/100'
8 SLOTS/ 100'
TRUCK LANE
5'
10'
3'
5'
PAD
5'
PAD
5'
10'
20'
PAD
5'
55'
30'
45'
45'
243'
55'
30'
PAD
5'
20'
5'
10'
PAD
1½'
5'

020 Crane With 2 Centre Storage Aisles

For every 100-foot section of 2-track module:
- 4 track slots
- 0 track slots 24,300 square feet in the working area
- 16 centre aisle slots

Note 1: The crane span is approximately 35 feet.

Appendix 4-2-12
030 Crane — 4 Track Module (Without Centre Aisle Storage)


100'
5'
10'
3'
5'
PAD
5'
PAD
5'
10'
6'
10'
20'
5' PAD
77½'
TRUCK LANE
15'
15'
TRUCK LANE
5' PAD
20'
77½'
10'
6'
10'
5'
5' PAD
1½'

030 Crane Without Centre Aisle Storage

For every 100-foot section of 2-track module:

- 4 track slots
- 2 trackside slots
- 0 centre aisle slots

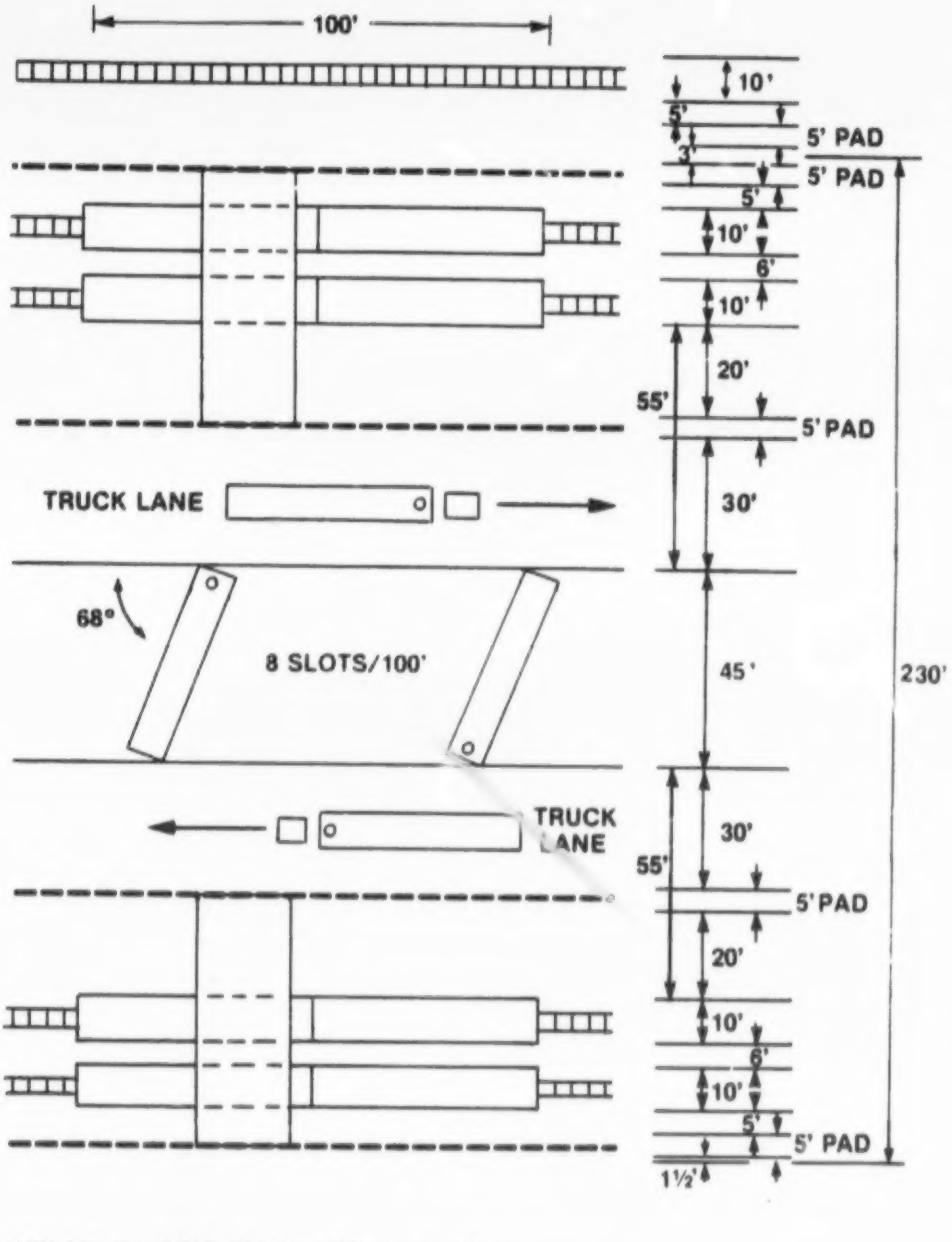
7,750 square feet in the working area

Note 1: The crane span is approximately 56 feet.

Note 2: This layout shows a "transfer" terminal with hostling to remote storage.

Note 3: A lift-over capability would permit the crane to unload the inner track before unloading the outer track.

Appendix 4-2-13
030 Crane — 4 Track Module
(With Center Storage Aisle)


100'
10'
5'
5' PAD
3'
5' PAD
5'
10'
6'
10'
20'
55'
5'PAD
TRUCK LANE
30'
68°
8 SLOTS/100'
45'
230'
TRUCK LANE
30'
55'
5'PAD
20'
10'
6'
10'
5'
5' PAD
1½'

030 Crane With Center Storage Aisle

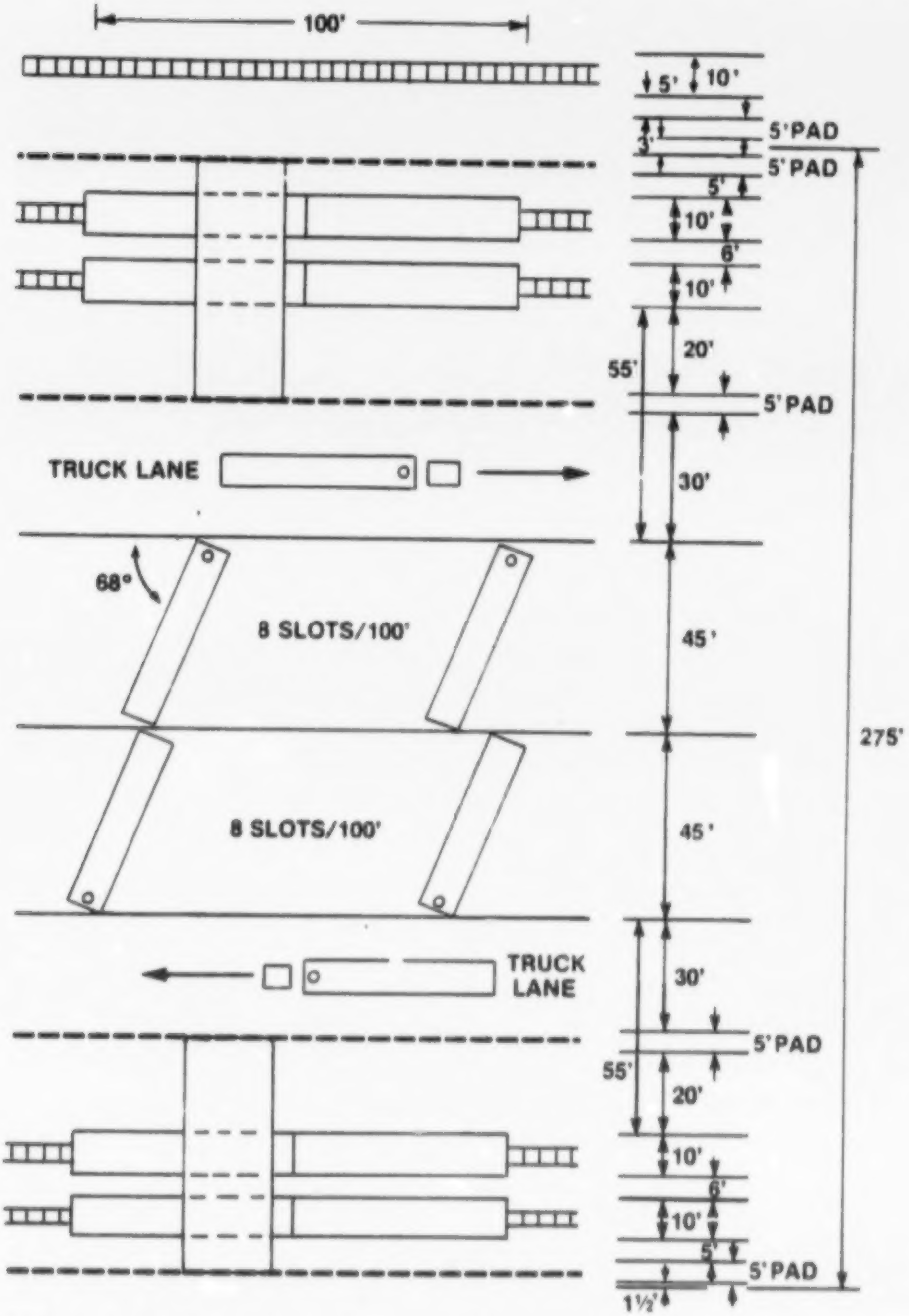
For every 100-foot section of 2-track module:

- 4 track slots
- 0 trackside slots 11,500 square feet in the working area
- 4 center aisle slots

Note 1: The crane span is approximately 56 feet.

Note 2: A lift-over capability would permit the crane to unload the inner track before unloading the outer track.

Appendix 4-2-14
030 Crane — 4 Track Module
(With 2 Center Storage Aisles)


100'
5'
10'
5'PAD
3'
5'PAD
5'
10'
6'
10'
20'
55'
5'PAD
TRUCK LANE
30'
68°
8 SLOTS/100'
45'
275'
8 SLOTS/100'
45'
TRUCK LANE
30'
5'PAD
55'
20'
10'
6'
10'
5'
5'PAD
1½'

030 Crane With 2 Center Storage Aisles

For every 100-foot section of 2-track module:

- 4 track slots
- 0 trackside slots 13,750 square feet in the working area
- 8 center aisle slots

Note 1: The crane span is approximately 56 feet.

Note 2: A lift-over capability would permit the crane to unload the inner track before unloading the outer track.

Annex 4.2.15 Summary of Standard Trailer and Equipment Layouts

Annex Number	Handling Equipment	Tracks	Type	Description of Layout and Storage Arrangements	For Every 4 Track Slots Working Area Required	Track side Slots	Centre Aisle Slots	Total Storage Slots	Working area Required per Storage Slot	Space Efficiency Ranking	Hostling Needs (sq.ft.)
4.2.1	CLR	10	T	Long tracks	5,000	0	0	0	-	-	100%
4.2.2	CLR	12	T	Short tracks	6,000	0	0	0	-	-	100%
4.2.3	P or C	2	I	"Sprint" train - trackside storage only	17,000						
4.2.4	P	2	T	Without centre storage aisle	10,000	4	0	4	2,525	9	High
4.2.5	P	2	I	With trackside and centre aisle storage	17,600	4	4	8	2,200	7	Medium
4.2.6	P	2	I	With trackside and centre aisle storage	22,100	4	8	12	1,842	4	Medium
4.2.7	P	2	I	With centre storage aisle	17,100	0	8	8	2,138	6	Medium
4.2.8	P	2	I	With 2 centre storage aisles	22,600	0	16	16	1,413	1	Low
4.2.9	020C	2	T	Without centre storage aisle	12,300	4	0	4	3,075	11	High
4.2.10	020C	2	I	With centre storage aisle	19,800	0	8	8	2,475	8	Medium
4.2.11	020C	2	I	With 2 centre storage aisles	24,300	0	16	16	1,519	2	Low
4.2.12	030C	2	T	Without centre storage aisle	7,750	2	0	2	3,875	12	High
4.2.13	030C	2	I	With centre storage aisle	11,500	0	4	4	2,875	10	Medium
4.2.14	030C	2	I	With 2 centre storage aisles	13,750	0	8	8	1,719	3	Low

CLR = Circus Loading Ramp
P = Piggypacker
C = Crane
020C= 020 crane straddles a total of 2 trailers or rail cars or combination thereof and has no cantilever spans over the legs.
030C= 030 crane straddles a total of 3 trailers or rail cars or combination thereof and has no cantilever spans over the legs.
T = Transfer terminal with less than 50% of the storage requirements located in the working area, and a high demand for hostling.
I = Integrated terminal with at least 50% of the storage requirements located in the working area.

Annex 4.3 Terminal Design Parameters for Marine Containers

Annex 4.3.1 Marine Container Space Requirements

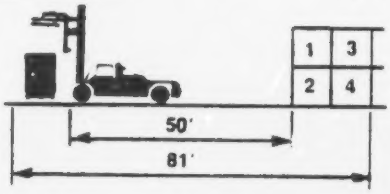
Marine containers have exterior dimensions of 8 feet in width and 20 feet or 40 feet in length. In order to allow for the small inaccuracies inherent with the handling equipment employed in typical terminals, the space allocated for 20-foot and 40-foot containers is 9.0 X 21.5 feet and 9.0 feet X 43.0 feet respectively. Toplifters are assumed to be able to maneuver a 40-foot container from a rail car and place it into a storage pile located 50 feet from the side of the rail car. Domestic Containers and trailers require 55 feet because they are longer.

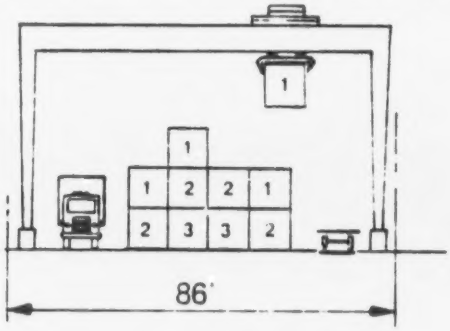
Annex 4.3.2 Loading and Unloading Requirements

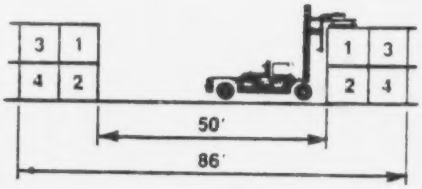
Containers are loaded onto rail cars so that the doors of the containers at the end of the car face inboard in order to prevent pilferage. This procedure results in the random location of the doors when the containers arrive at the terminal. With foreknowledge of the direction each container faces, the tractor and chassis can approach the transfer operation from the proper direction. When containers are loaded outbound from a stockpile, however, the handling equipment must have the ability to rotate the containers 180 degrees in order to position them properly on the rail cars. Toplifters have this ability because of their sharp turning abilities. Cranes, however, require the installation of a rotating spreader bar in order to achieve this flexibility.

Annex 4.3.3 Standard Terminal Layouts for Loaded Marine Containers

	Per 100 Foot Section						
In Terminal Working Area	TEU per X-section	TEU per 100 feet	Total TEU	Area in Sq. Ft.	Square Feet per TEU	Max. No. Cycles	Avg. No. Cycles
a) Toplifter and 2 X 2 Stockpiles	4	4.65	18.6	8,100	435.5	4	2.5
b) 060 Crane and 2-3-3-2 Stockpile	10	4.65	46.65	8,600	185.0	3	1.8
In Remote Storage Areas							
c) Toplifter and 2 X 2 Stockpiles	8	4.65	37.2	8,600	231.2	4	2.5
d) 060 Crane and 2-3-3-3-3-2 Stockpile	16	4.65	74.4	8,600	115.6	3	1.9




1
1
1
2
2
1
2
3
3
2
86'


3
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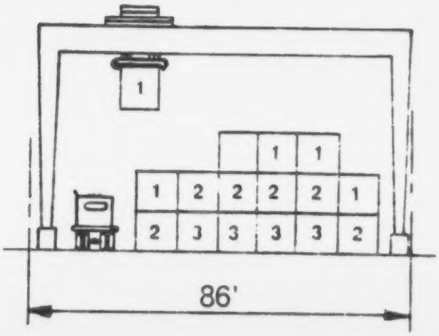
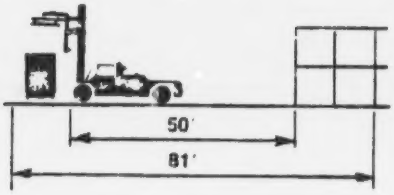
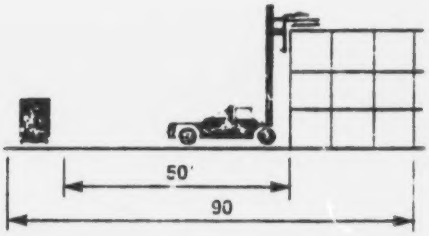
4
50'
86'

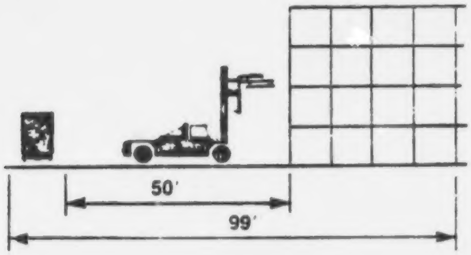

1
1
1
1
2
2
2
2
1
2
3
3
3
3
2
86'

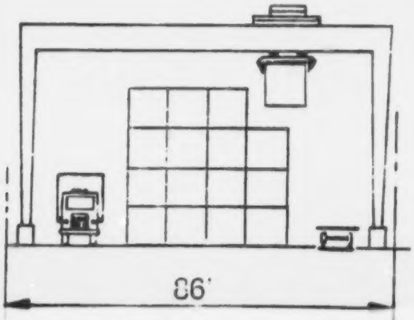
Annex 4.3.4. Standard Terminal Layouts for Empty Marine Containers in Terminal Working Area

	Per 100 Foot Section				
	TEU per X-section	TEU per 100 feet	Total TEU	Area in Sq. Ft.	Square Feet per TEU
a) Toplifter and 2 X 2 Stockpiles	4	4.65	18.6	8,100	435.5
b) Toplifter and 3 X 3 Stockpiles	9	4.65	41.85	9,000	215.1
c) Toplifter and 4 X 4 Stockpiles	16	4.65	74.4	9,900	133.1
d) 060 Crane and 4 X 4 Stockpile	16	4.65	74.4	8,600	115.6



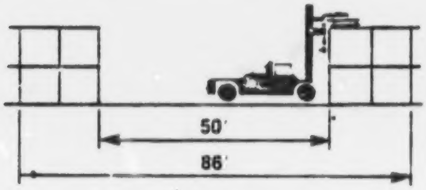


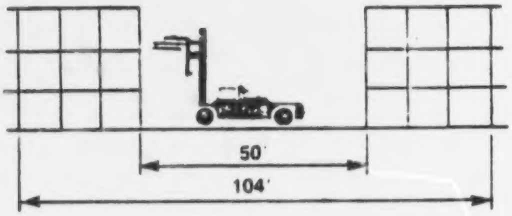


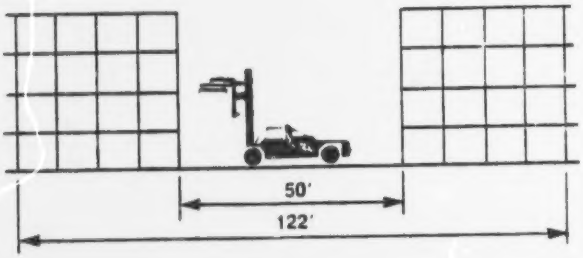


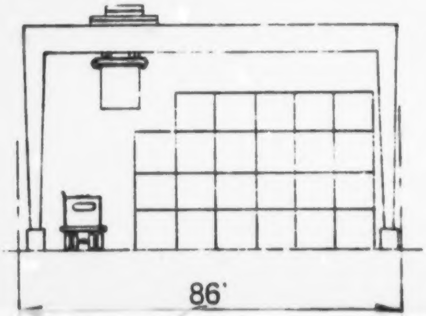
Annex 4.3.5 Standard Terminal Layouts for Empty Marine Containers in Remote Storage Areas

	Per 100 Foot Section				
	TEU per X-section	TEU per 100 feet	Total TEU	Area in Sq. Ft.	Square Feet per TEU
a) Toplifter and 2 X 2 Stockpiles	8	4.65	37.2	8,600	231.2
b) Toplifter and 3 X 3 Stockpiles	18	4.65	83.7	10,400	124.3
c) Toplifter and 4 X 4 Stockpiles	32	4.65	148.6	12,200	82.0
d) 060 Crane and 6 X 4 Stockpile	24	4.65	111.6	8,600	77.1









APPENDIX IV

INTERMODAL TRANSPORTATION AND HANDLING EQUIPMENT

TABLE OF CONTENTS

Section 1: Intermodal Freight Equipment

Section 2: Equipment Used at Intermodal Terminals Featuring Ramp Operations

Section 3: Intermodal Terminals Featuring Conventional Trailer/ Container Side and Overhead Lifting Equipment

Section 4: Intermodal Terminal Equipment for Low-Volume or Special Applications

Section 5: Equipment for Intermodal Terminals for High-Rise, High-Density Storage and Retrieval Systems

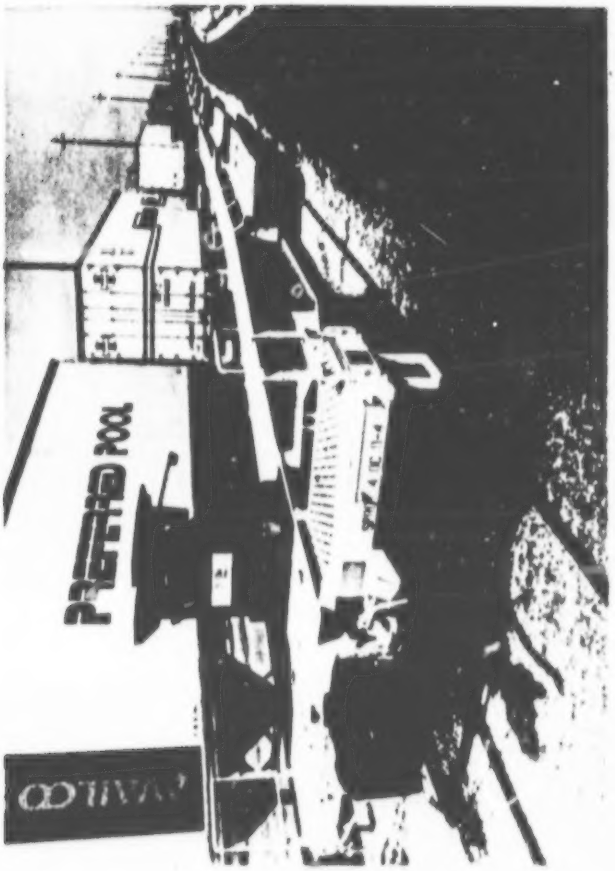
A general photographic survey of the technology for truck, rail, and marine terminals, ranging from toplifting equipment to automated conventional high-rise container warehouses.

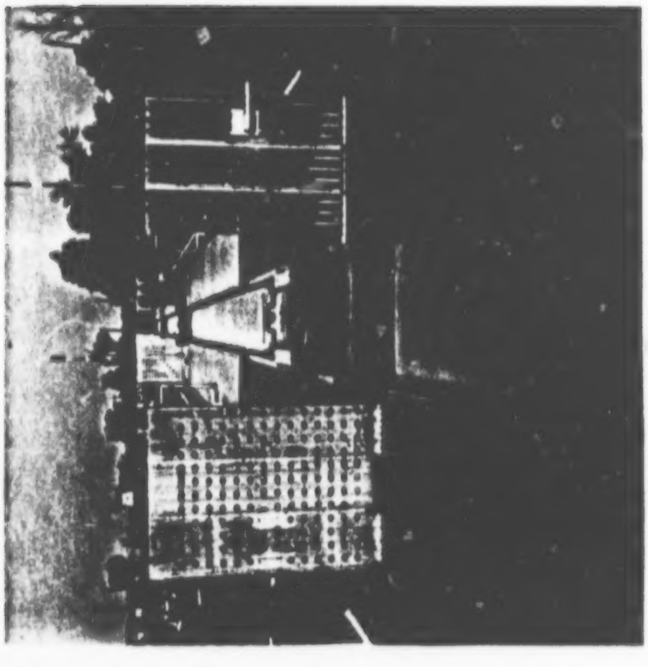
SECTION 1

INTERMODAL FREIGHT EQUIPMENT

Train of trailer flat cars with aprons raised ready for transit.

A skeletal articulated trailer flat-car. The trailer wheels rest on the low platforms. A permanent raised hitch is provided. These flat-cars can only be side-loaded.


PREFERRED POOL
VALCO

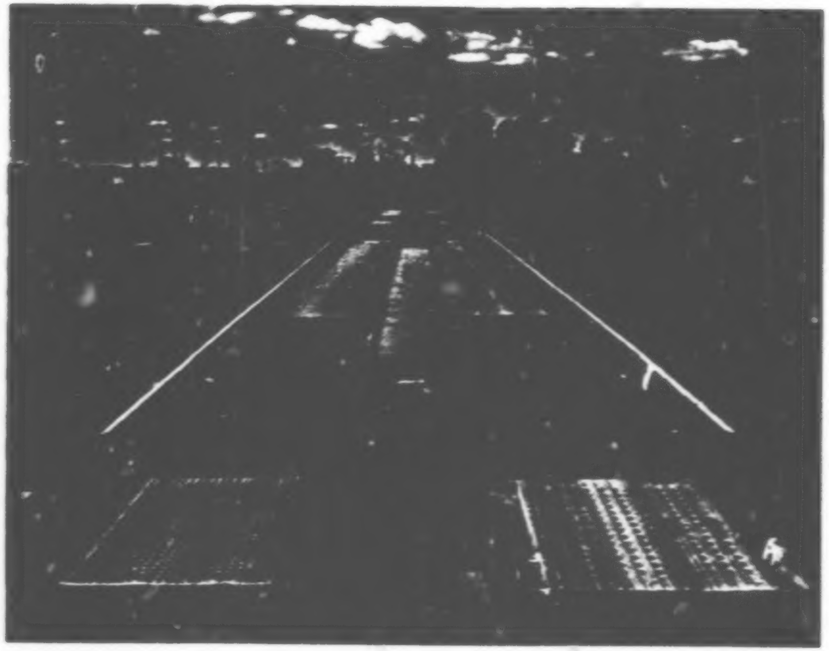


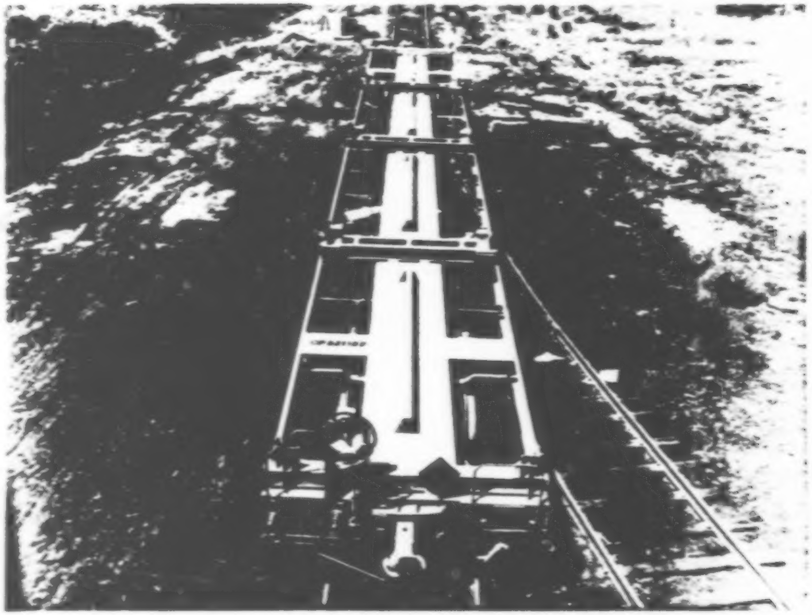
A view of a train of trailer flat-cars with aprons lowered thus creating a "road" over which trailers can be loaded or unloaded.

An 8 foot "4 slot" skeletal marine (ISO) container flat car. This car will handle 2 X 40 foot or 4 X 20 foot containers. Containers must be side loaded. Domestic container cars are similar, being 89' long with capacity to handle 2 X 44' containers or 3 X 29' containers in addition to the marine containers. A different view of a Domestic container chassis.

A Domestic container chassis hitched to a tractor. In the background, a stack of Domestic containers can be seen.

Another view of a Domestic container chassis. Marine container chassis for 40' containers are similiar.





CP Rail
CP Rail
CP Rail
CP Rail

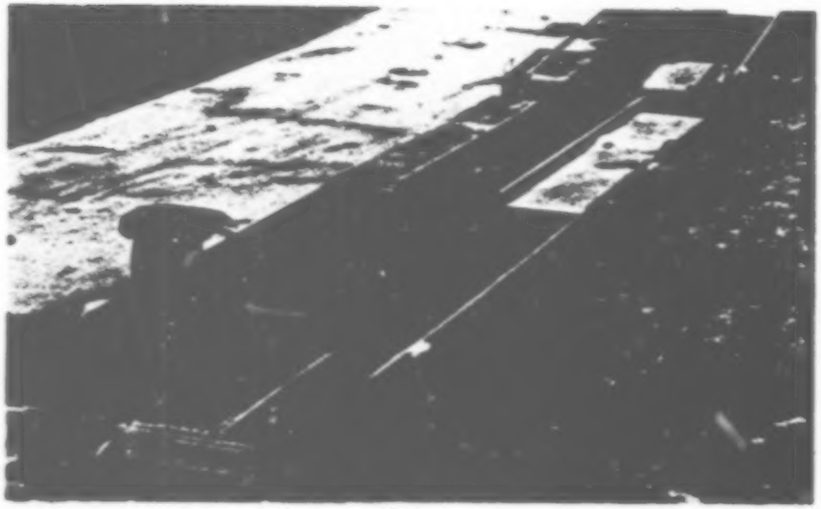
CPPZ 165029 TARE

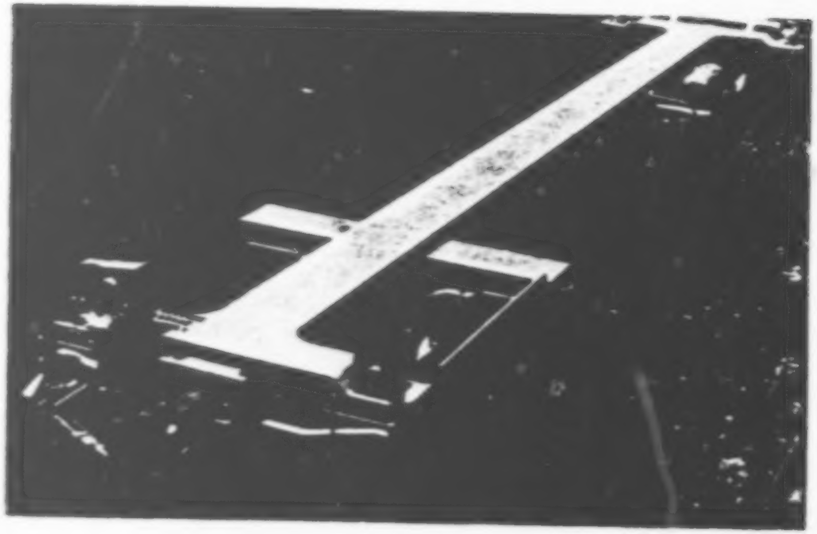
A multi-unit, single axle car for trailers up to 45 ft. This car can handle nose-mounted reefer units.

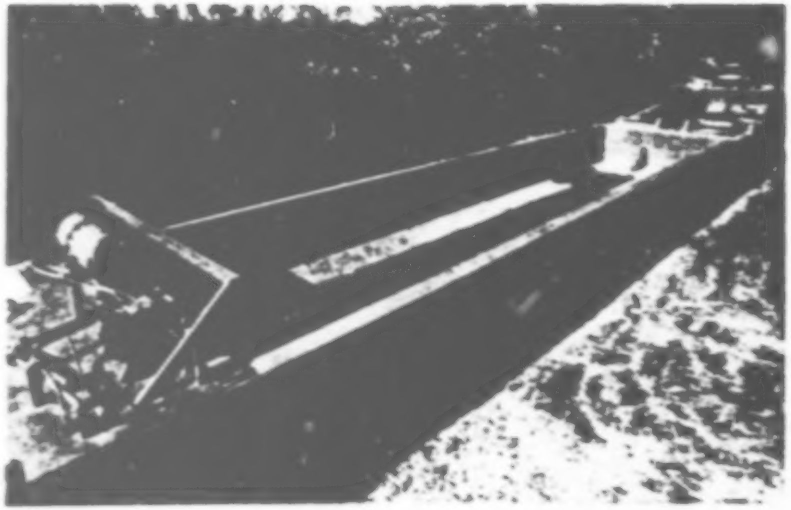
The most notable feature of this car is its low clearance. It can carry either containers or trailers, and is a articulated car.

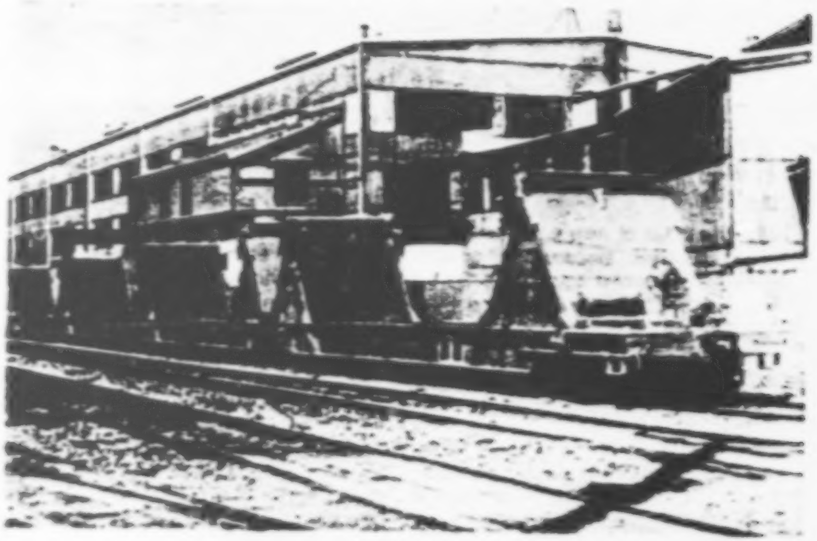
This photo shows a single section of a 4 section articulated car. Each will carry one 40' container. This car features a very low tare weight.

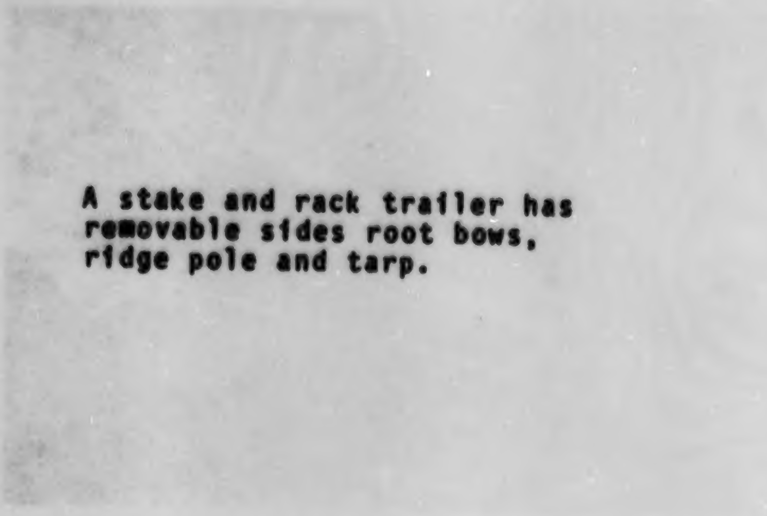
This car carries containers double stacked. The bulkheads hold the top container firmly. Use of this articulated car effectively increases terminal track capacity.



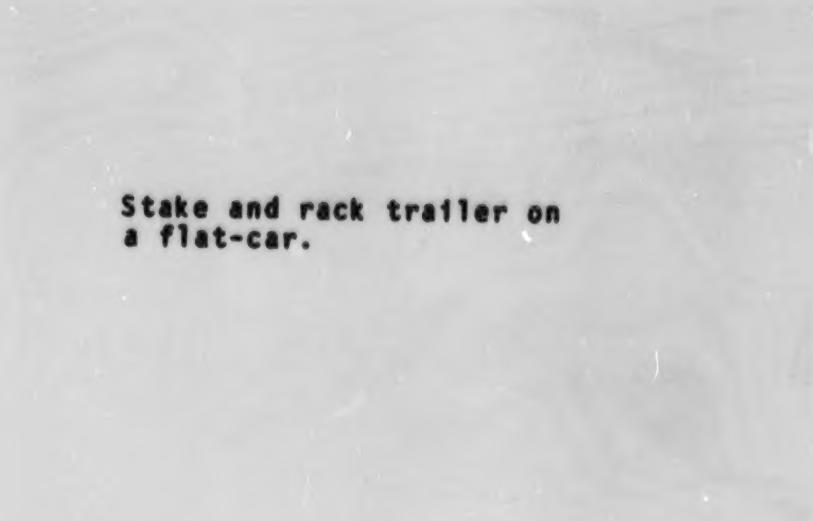




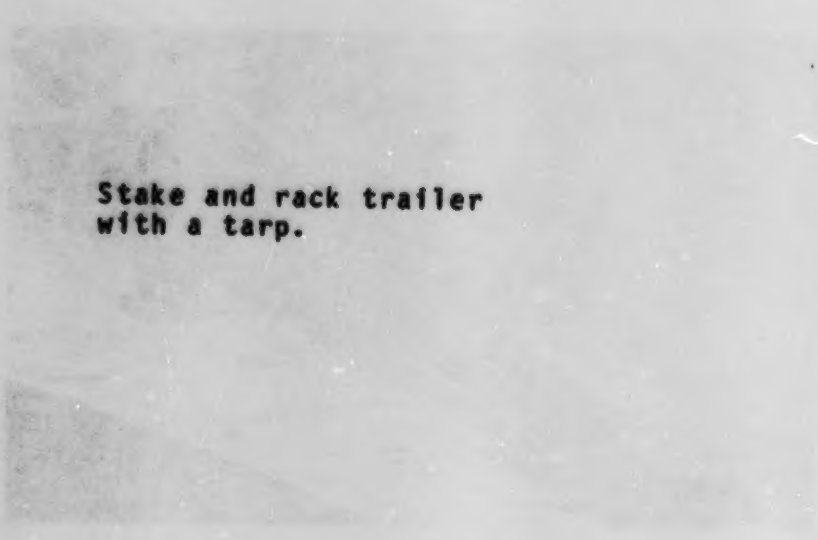




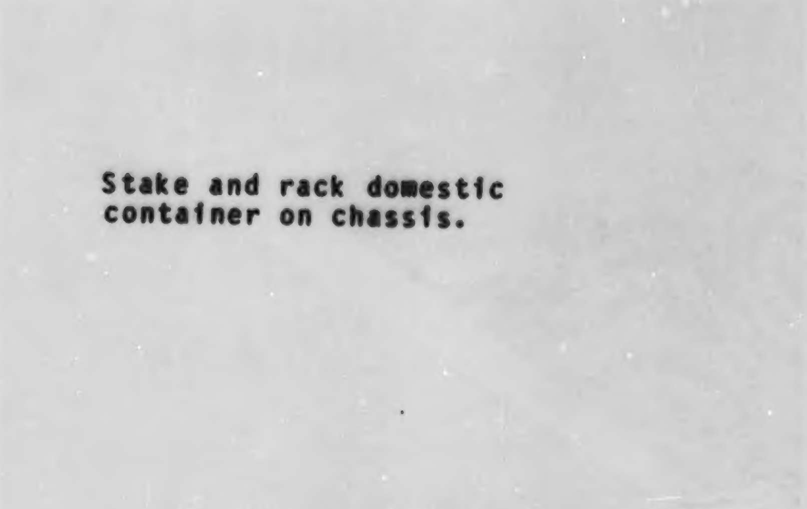
A stake and rack trailer has removable sides root bows, ridge pole and tarp.



Stake and rack trailer on a flat-car.

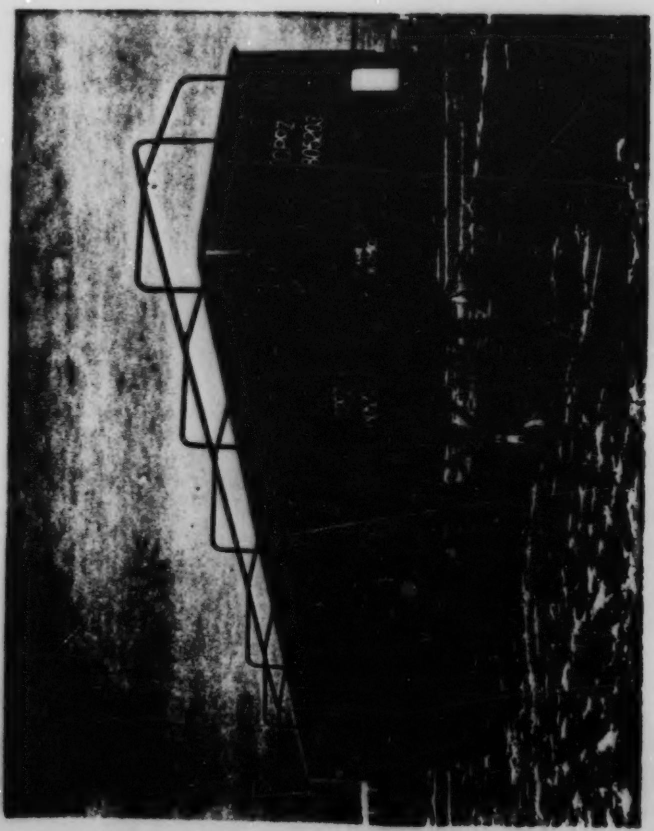


Stake and rack trailer with a tarp.



Stake and rack domestic container on chassis.

CPPZ
805226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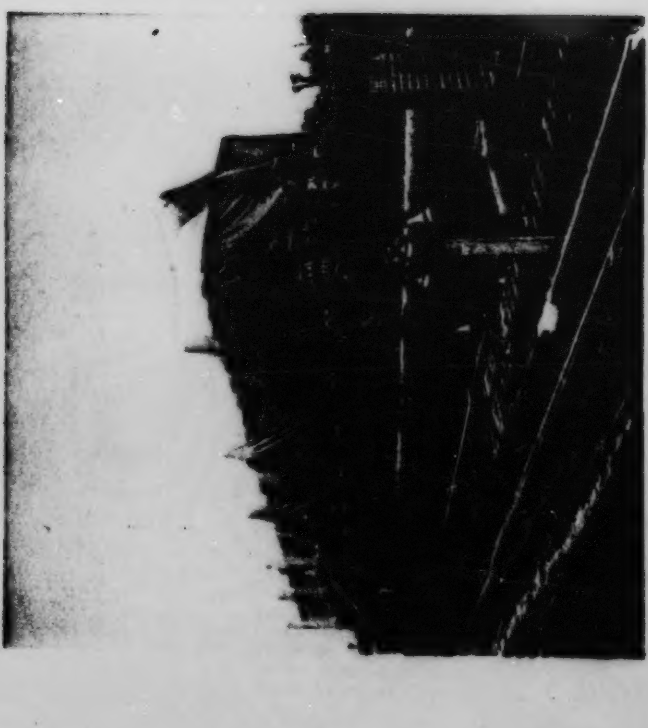

Front three quarter view of a refrigeration unit found on a trailer. Also shown is a partlow recording thermometer and a inspection document holder.

Refrigerated trailer (sometimes called "reefer") on a flat-car.

Refrigerated Domestic container on chassis hitched to a tractor.

Close up of an electric refrigeration unit.

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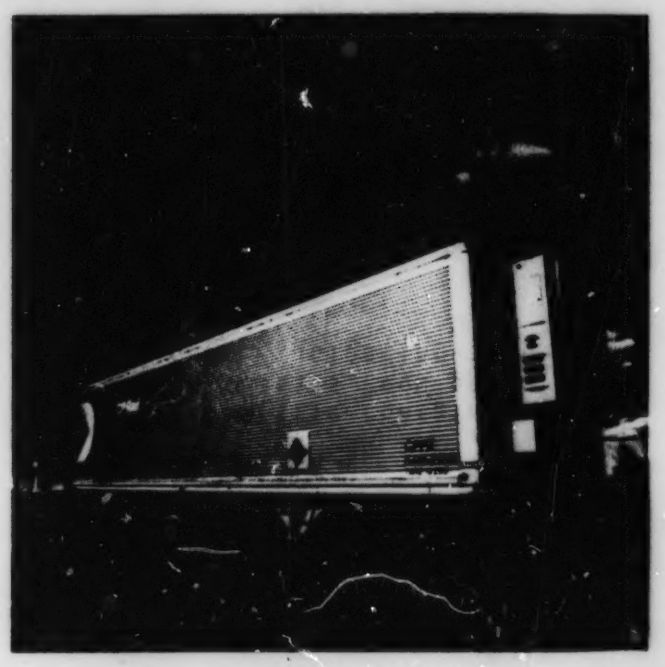
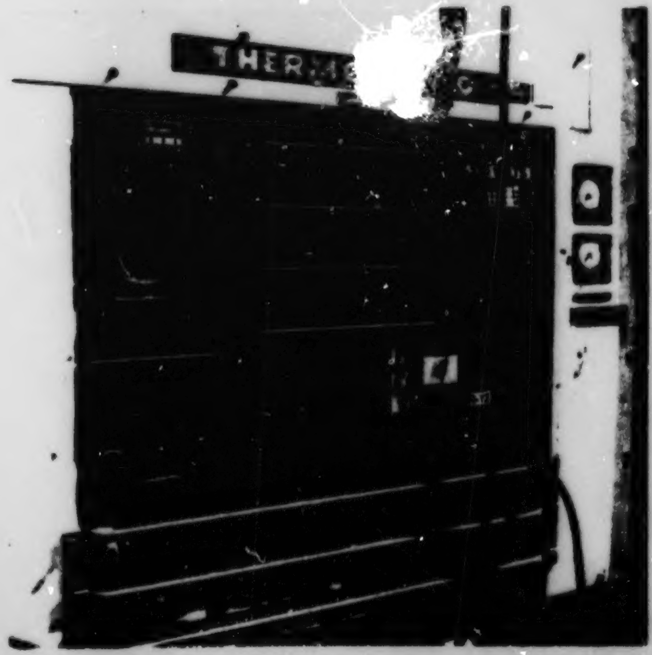
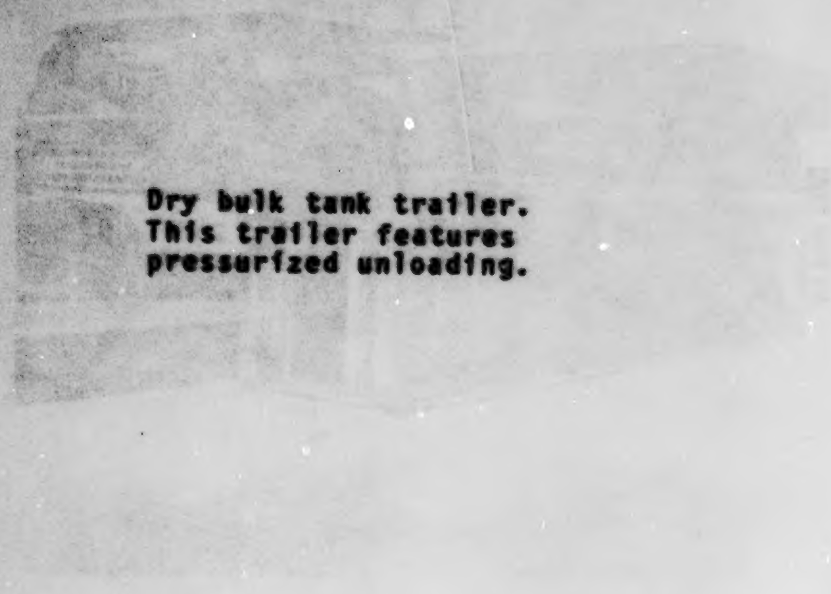
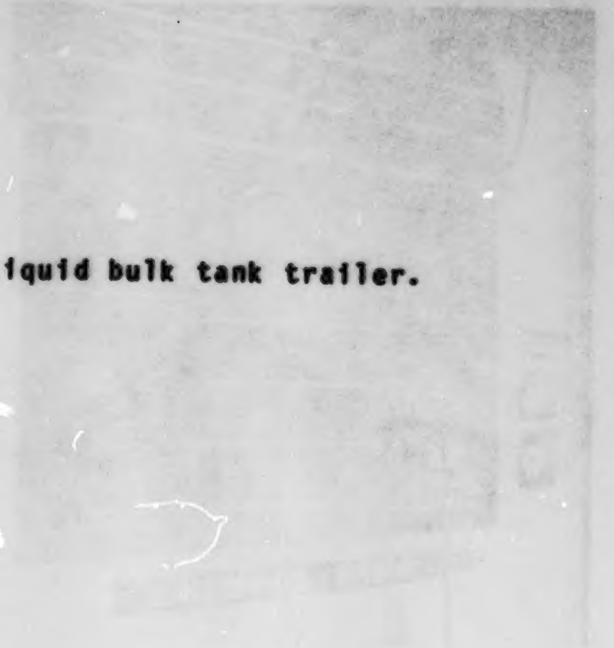
505509




THERM



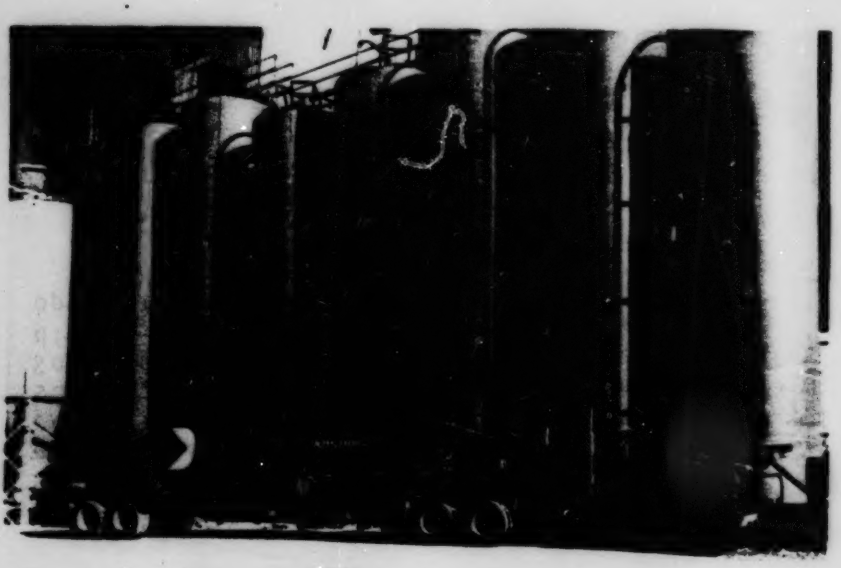
Dry bulk tank trailer.
This trailer features
pressurized unloading.

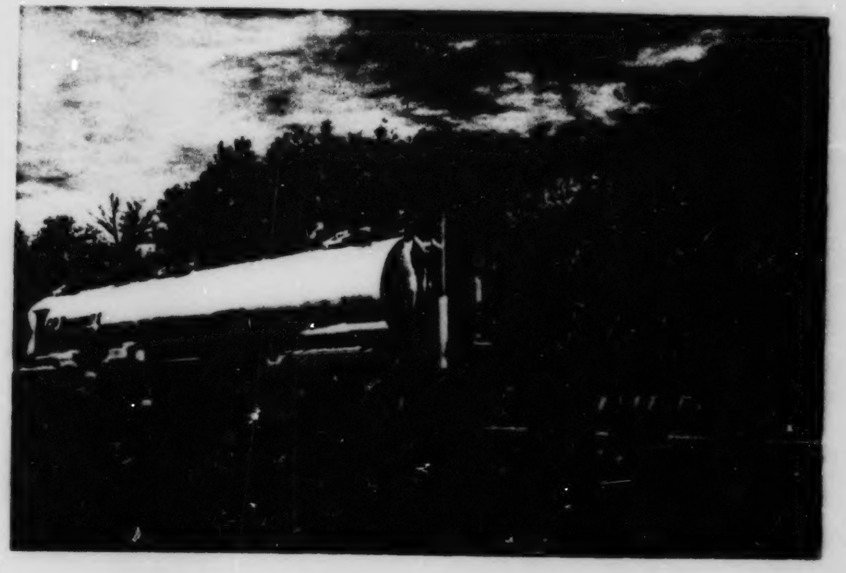


Liquid bulk tank trailer.

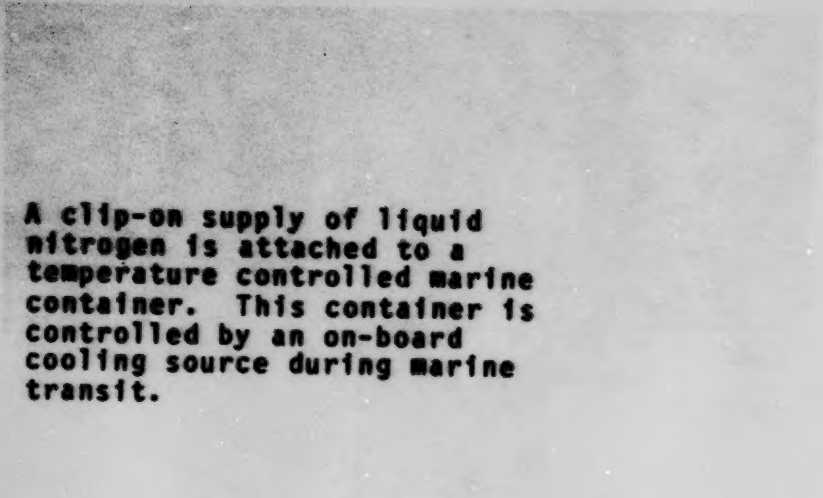
High Cube Domestic container
on chassis.

Dry bulk Domestic container
loaded on chassis, equipped
with vacuum - unloading system.

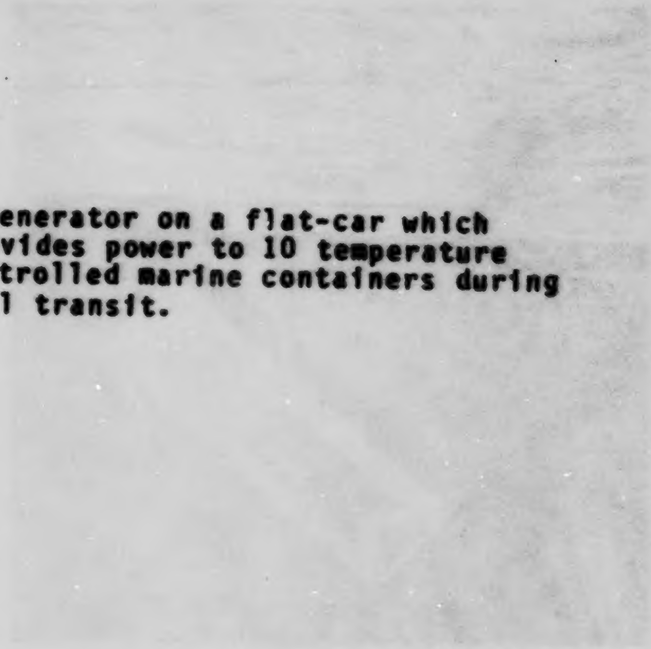




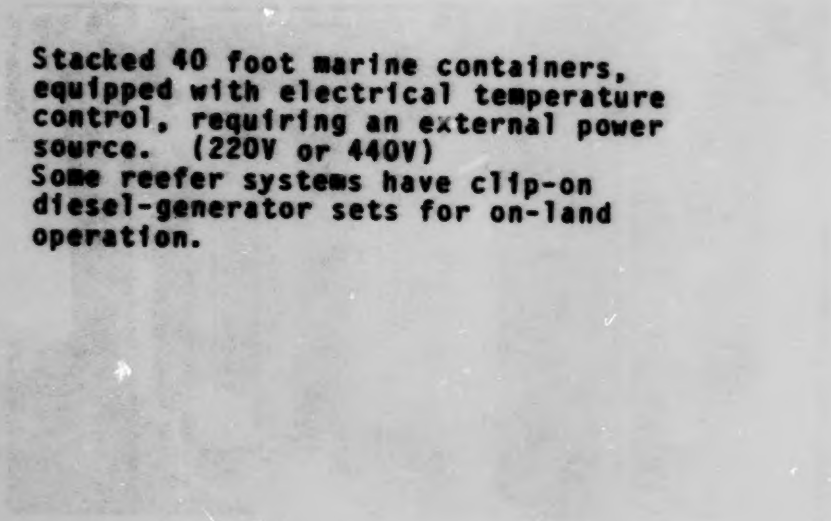
CP Rail



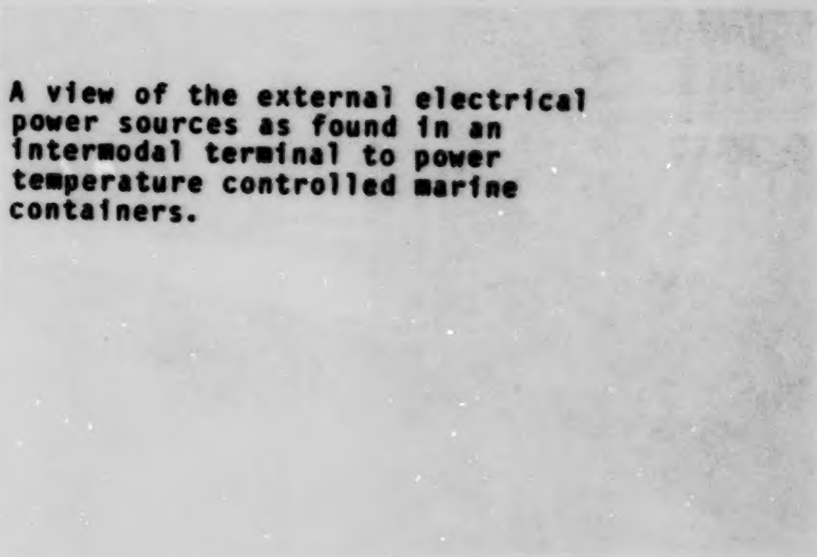
A clip-on supply of liquid nitrogen is attached to a temperature controlled marine container. This container is controlled by an on-board cooling source during marine transit.



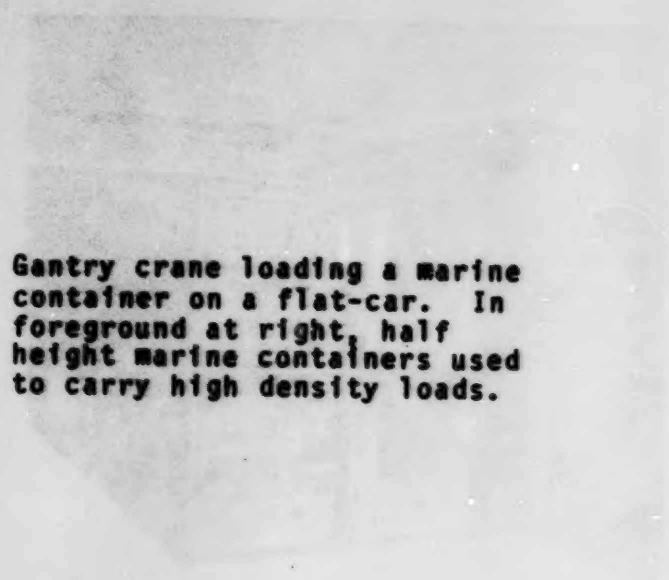
A generator on a flat-car which provides power to 10 temperature controlled marine containers during rail transit.



Stacked 40 foot marine containers, equipped with electrical temperature control, requiring an external power source. (220V or 440V)
Some reefer systems have clip-on diesel-generator sets for on-land operation.

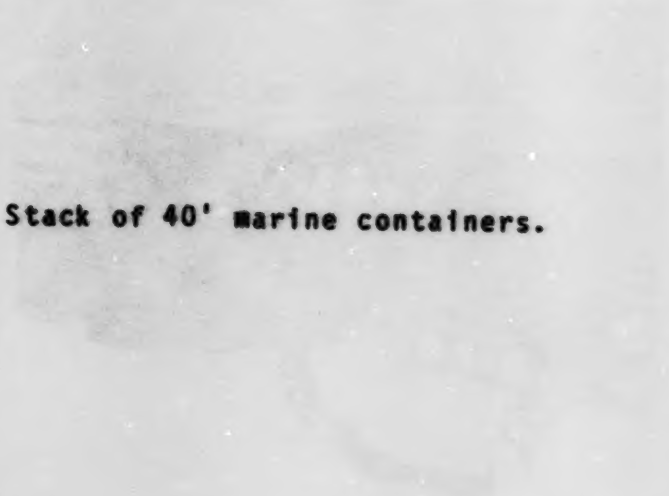


A view of the external electrical power sources as found in an intermodal terminal to power temperature controlled marine containers.

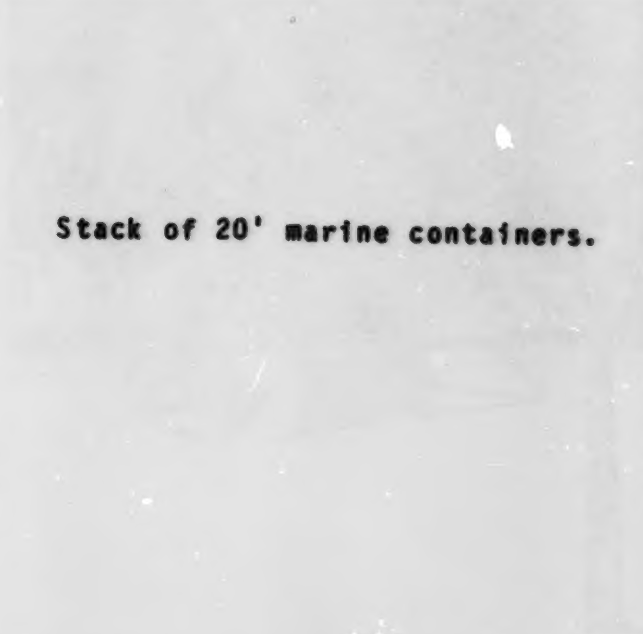


Gantry crane loading a marine container on a flat-car. In foreground at right, half height marine containers used to carry high density loads.

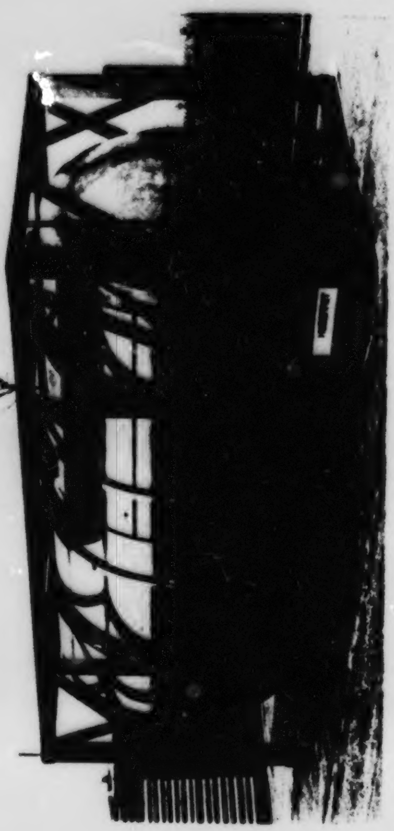
Tank for liquid commodities in a marine container frame.

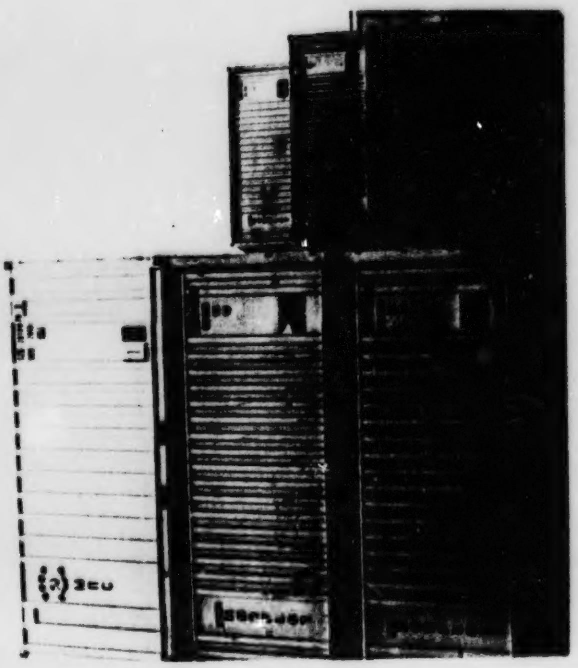


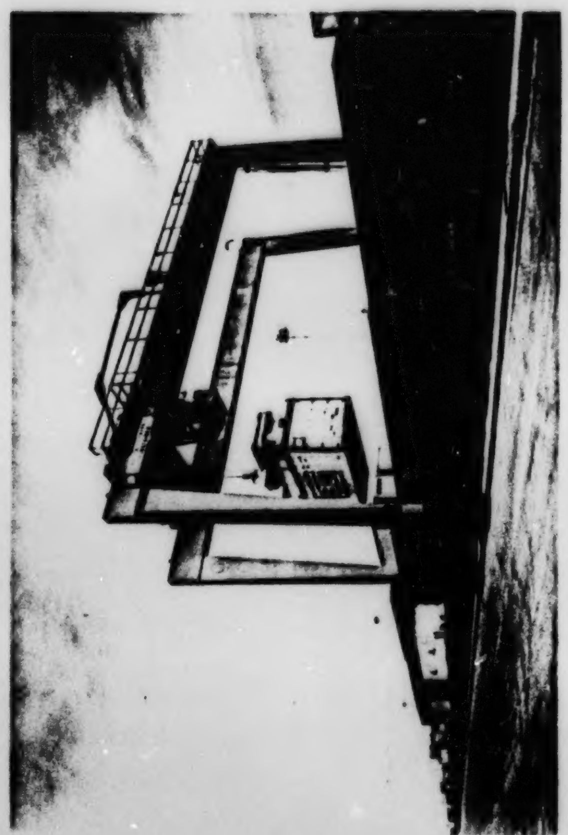
Stack of 40' marine containers.



Stack of 20' marine containers.







EQUIPMENT USED AT INTERMODAL TERMINALS FEATURING RAMP OPERATIONS

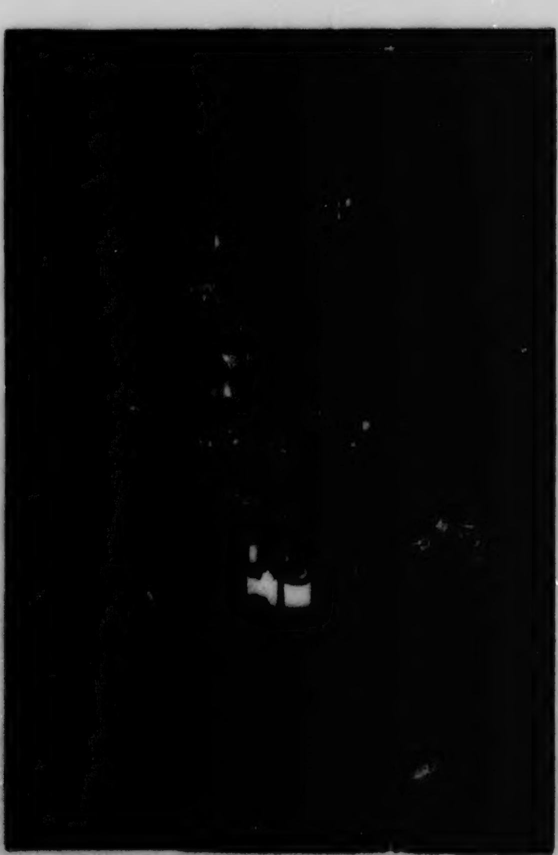
Aerial view of a typical intermodal terminal. This terminal uses ramps to load and unload trailers and four tracks to side-load marine containers.

Aerial view of trailer ramps.
In this case, ramps are staggered
to make loading tracks of equal
length.

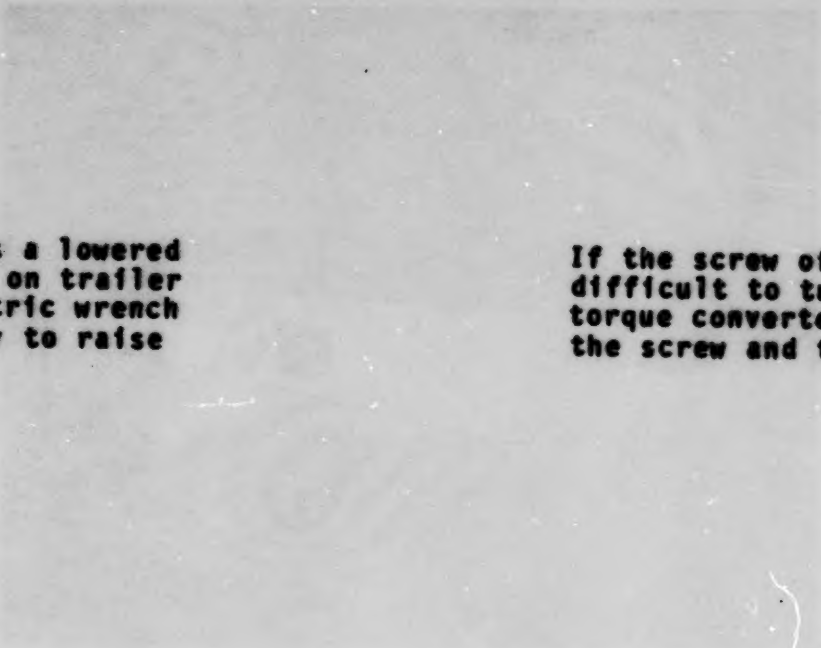
Front 3/4 view of a Hostling tractor used to load & unload trailers in circus ramp handling.

Back 3/4 view of Hostling tractor. Hydraulic fifth wheel allows the trailer to be moved without raising the landing gear.

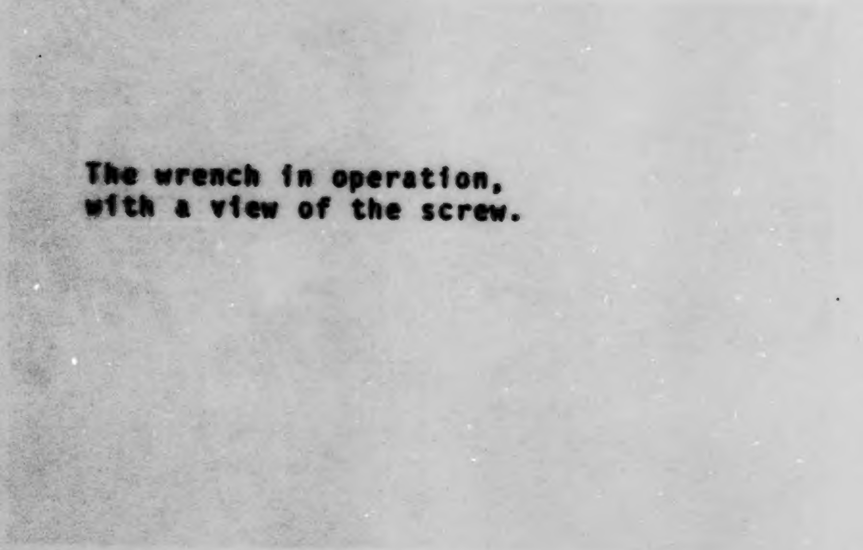
Hostling tractor in operation unloading a trailer from a flat-car over the ramp.



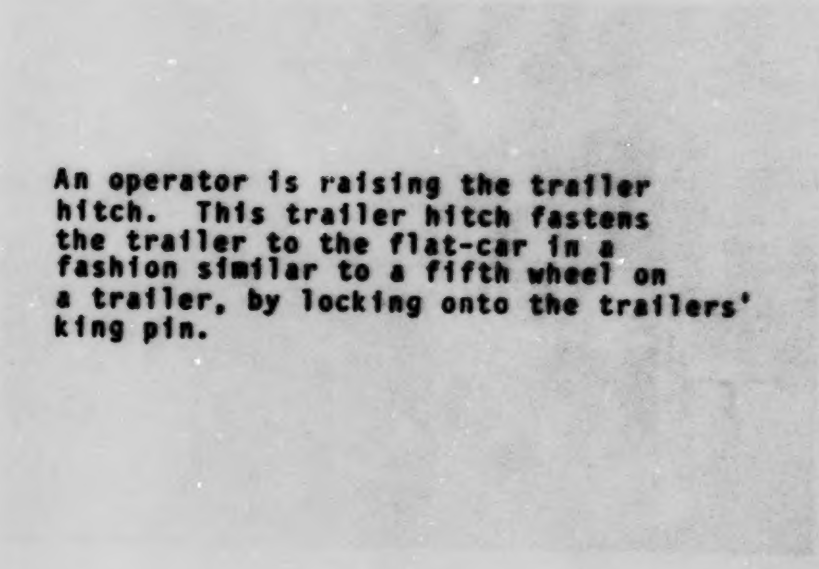
This picture depicts a lowered trailer hitch found on trailer flat-cars. An electric wrench is positioned, ready to raise the hitch.



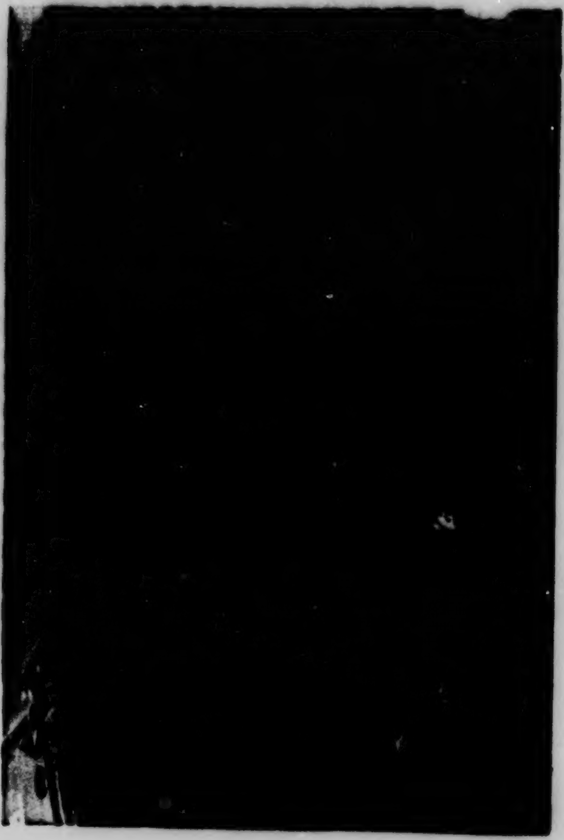
If the screw of the hitch is difficult to turn, a four-to-one torque converter is used between the screw and the wrench.

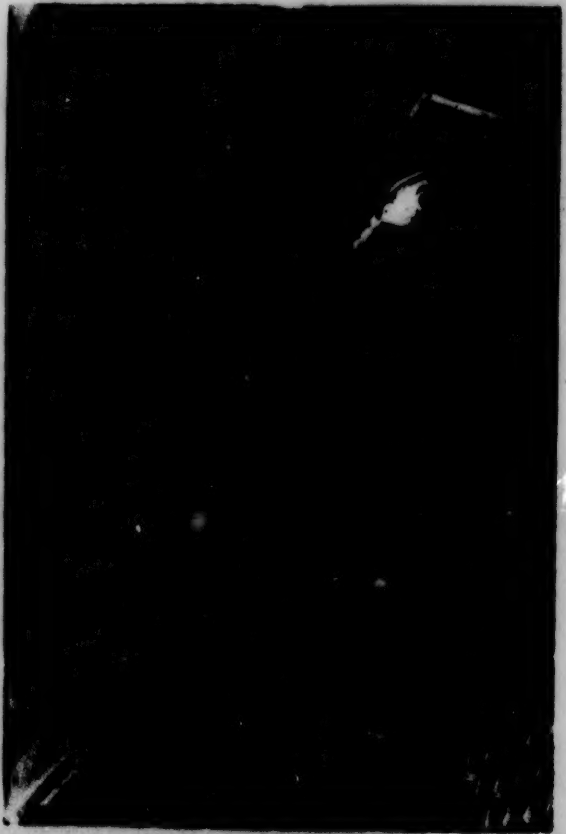


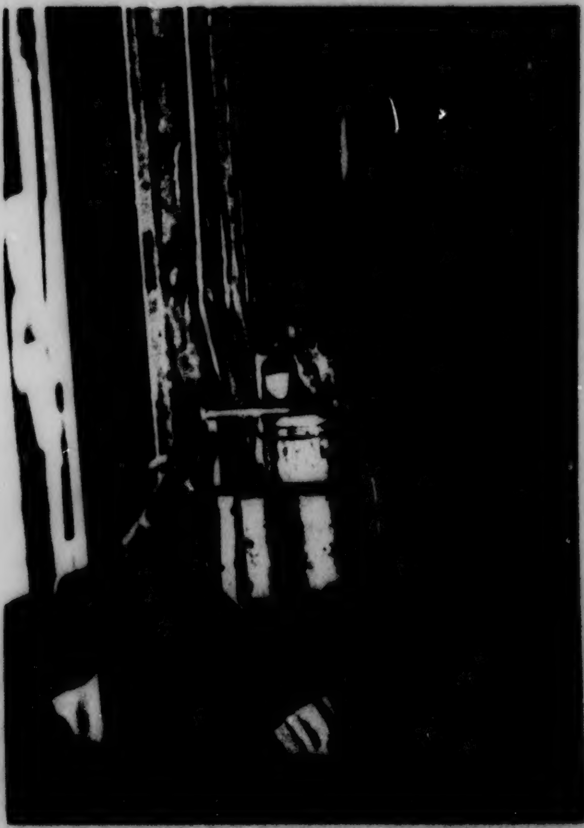
The wrench in operation, with a view of the screw.



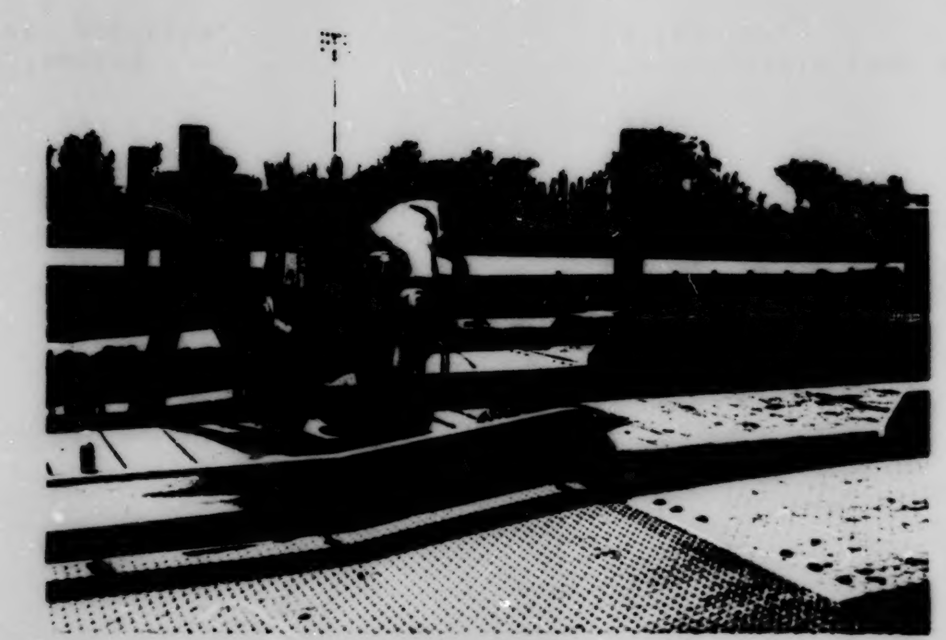
An operator is raising the trailer hitch. This trailer hitch fastens the trailer to the flat-car in a fashion similar to a fifth wheel on a trailer, by locking onto the trailers' king pin.







View of an operator using a portable generator to power the electric wrench which raises or lowers the trailer hitch on a flat-car.

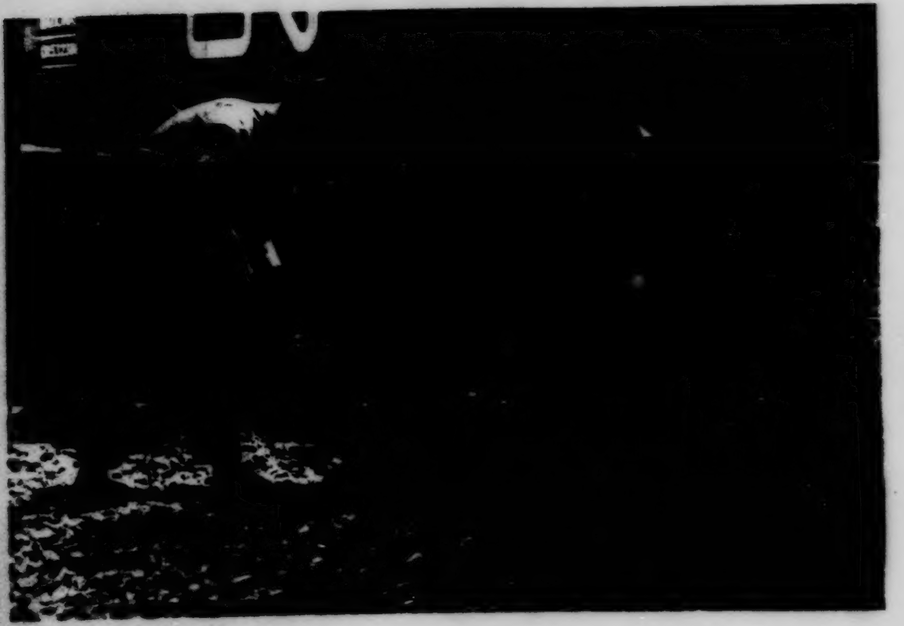


A portable ramp being trucked into position (the portable ramp requires a stub siding).

The portable ramp is backed up into position abutting the trailer flat-cars.

The ramp legs are lowered to fix the ramp into position.

The portable ramp in use loading a trailer.



SECTION 3

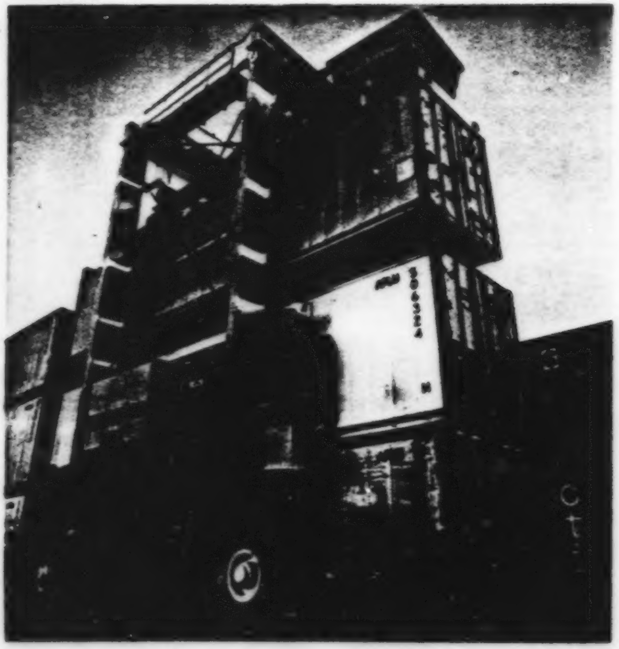
INTERMODAL TERMINALS FEATURING CONVENTIONAL TRAILER/CONTAINER SIDE AND OVERHEAD LIFTING EQUIPMENT

Straddle-carrier capable of stacking 40' marine containers three high.

Rubber-tyre steerable 070 Gantry crane.

View of an intermodal (road/rail) terminal with an 030 Gantry crane in use.

Rubber-tyre 020 Gantry crane used to stack 40' marine containers 3 high.



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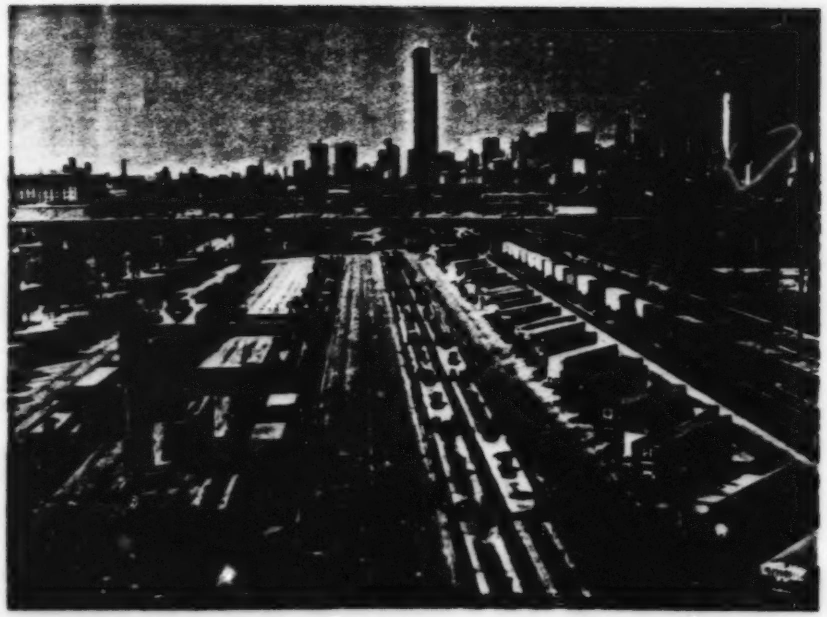
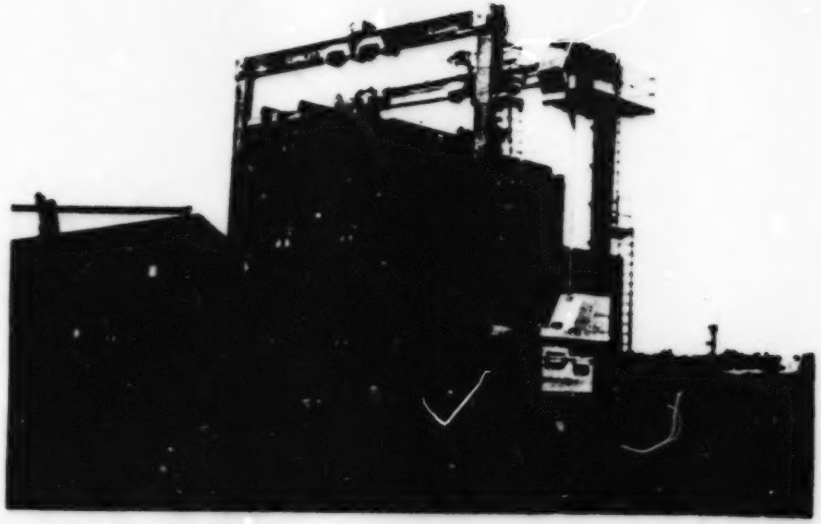


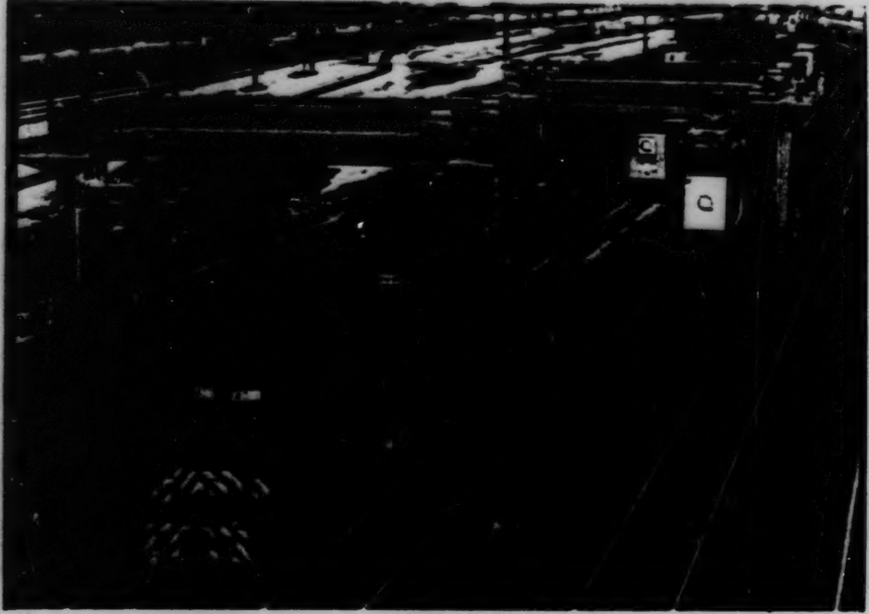


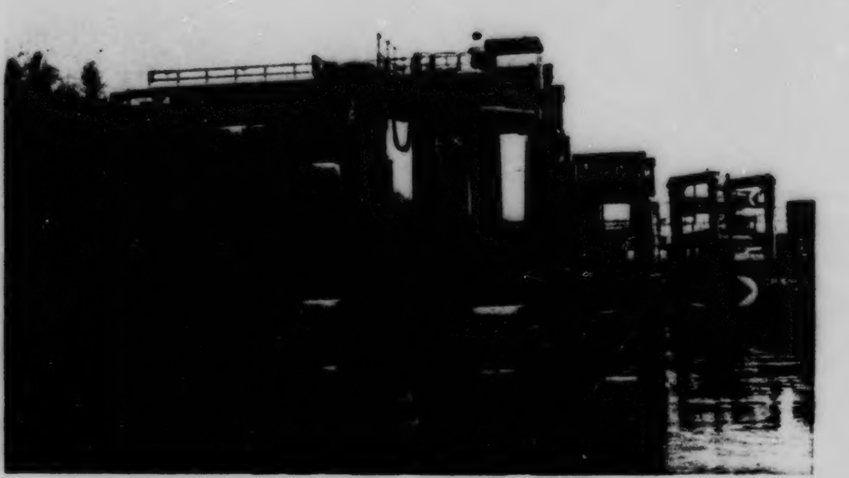
Two 020 rubber-tyre Gantry cranes straddling a common rail track and equipped to handle trailers.

Straddle carriers.

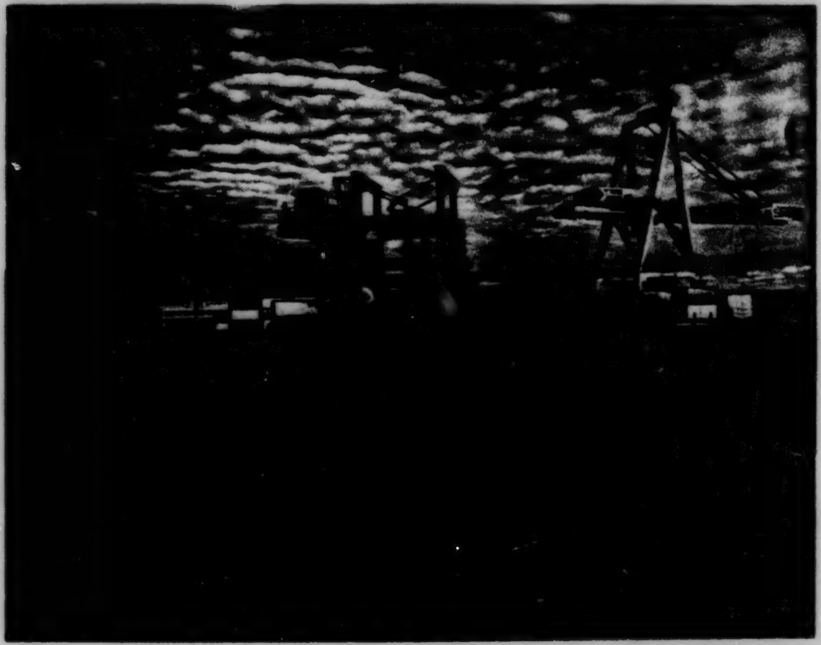
020 crane unloading a trailer from a flat-car.

Rubber tyre straddle carrier loading a container onto a chassis. In the background, a cantilever crane used to handle containers from ships.

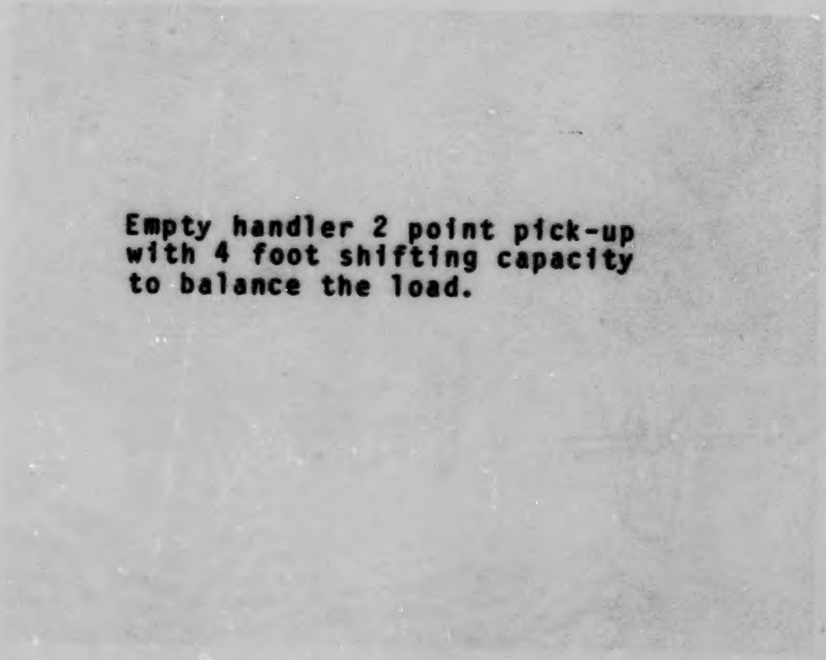




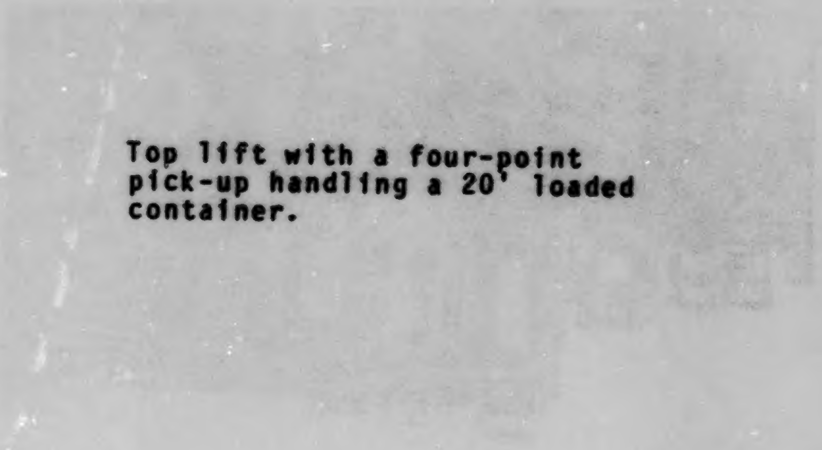
ST-100 Letro-port



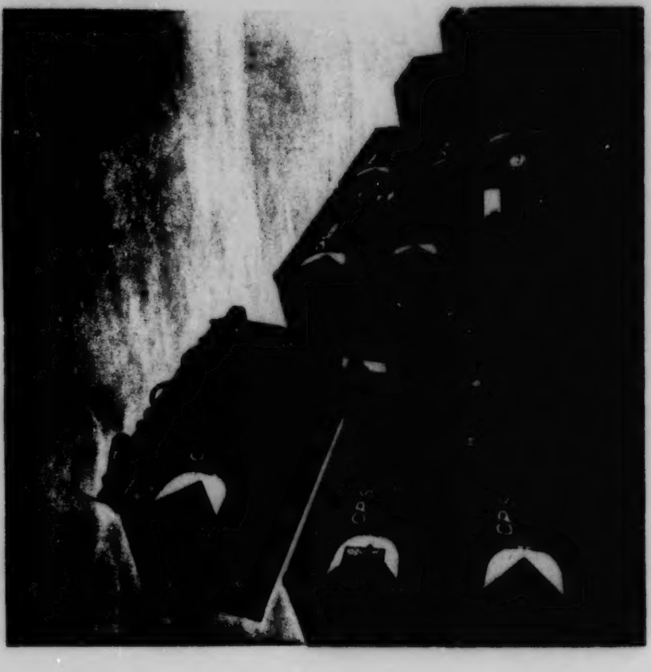
End stacking empty container handler.



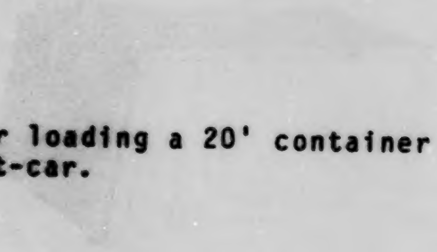
Empty handler 2 point pick-up with 4 foot shifting capacity to balance the load.



Top lift with a four-point pick-up handling a 20' loaded container.

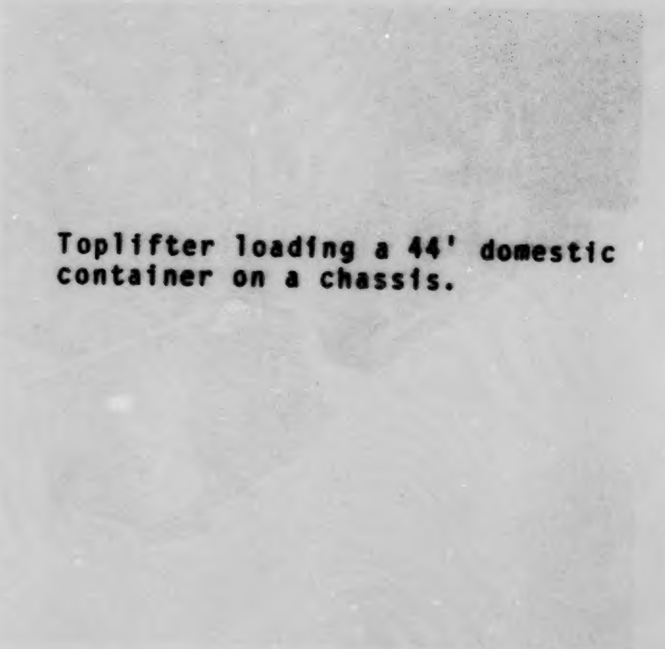


Front view of the toplifter
with spreader contracted for
a 20' container.

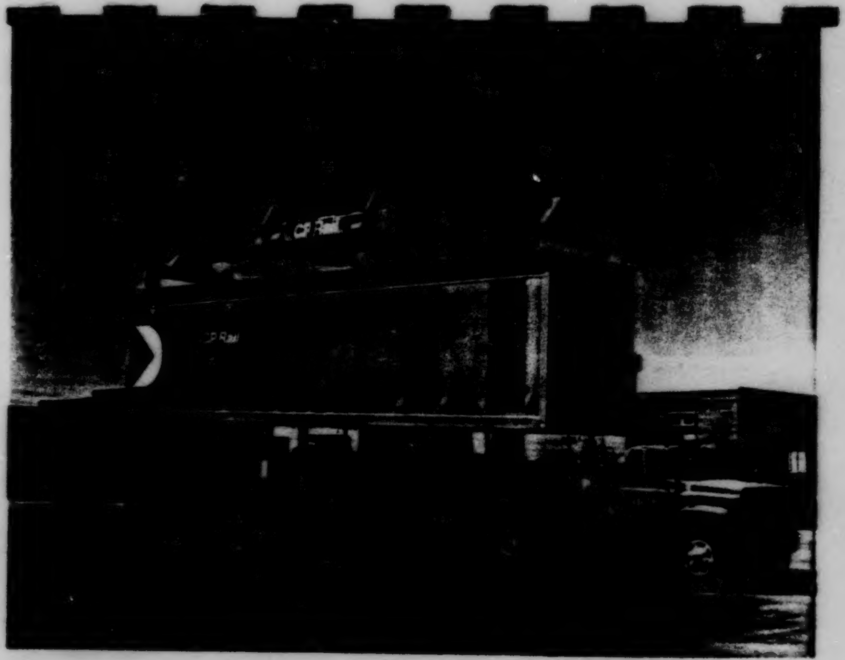


Toplifter loading a 20' container
on a flat-car.

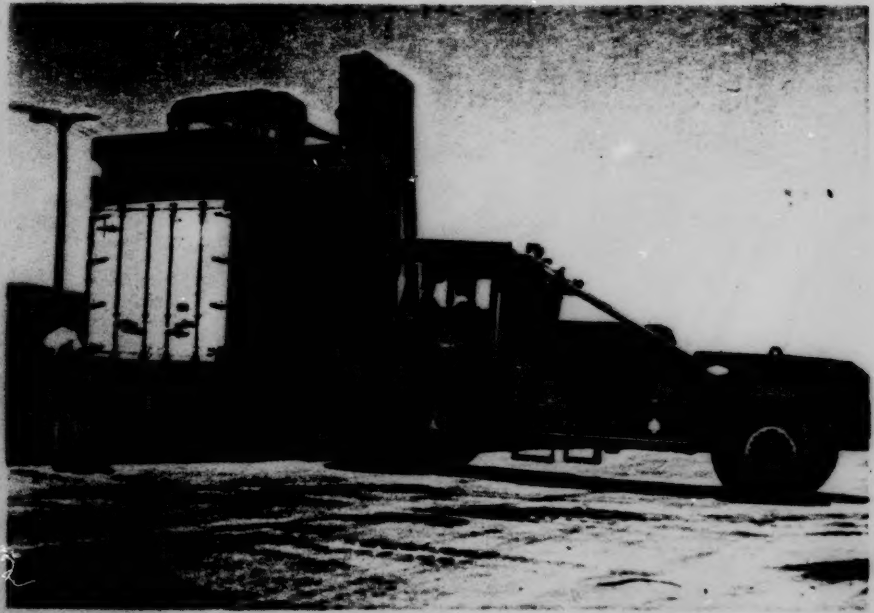
A toplifter with spreader extended
loading a 44' domestic container onto
a chassis hitched to a tractor.

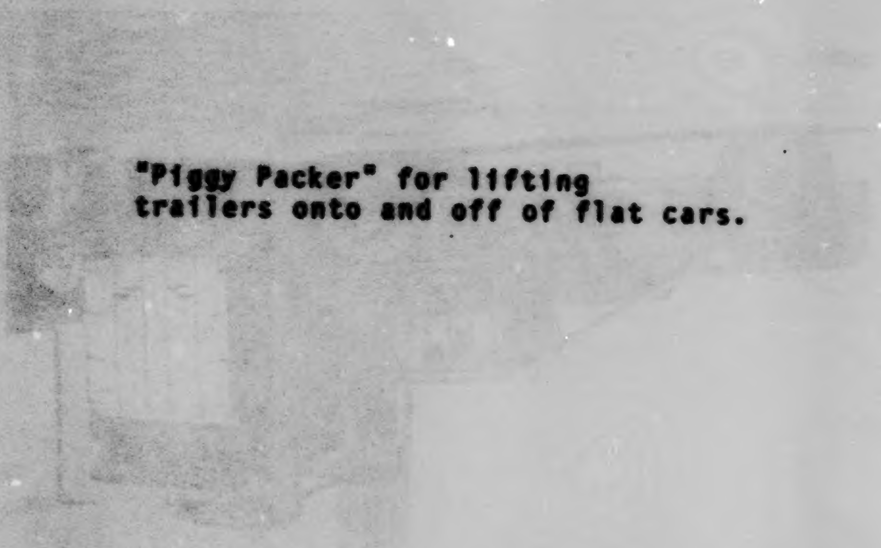


Toplifter loading a 44' domestic
container on a chassis.

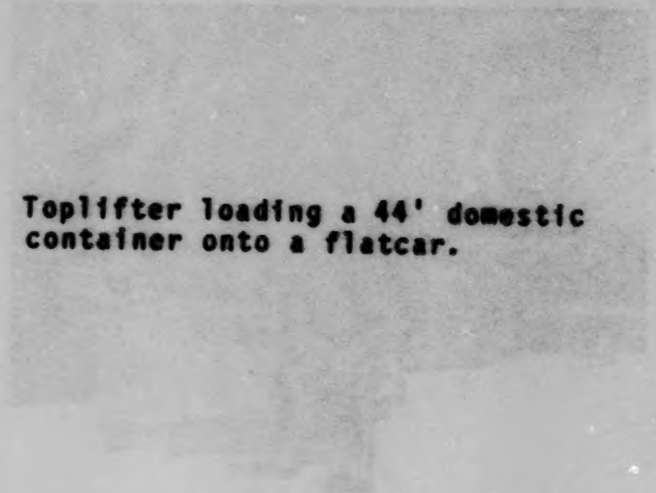


CP Rail

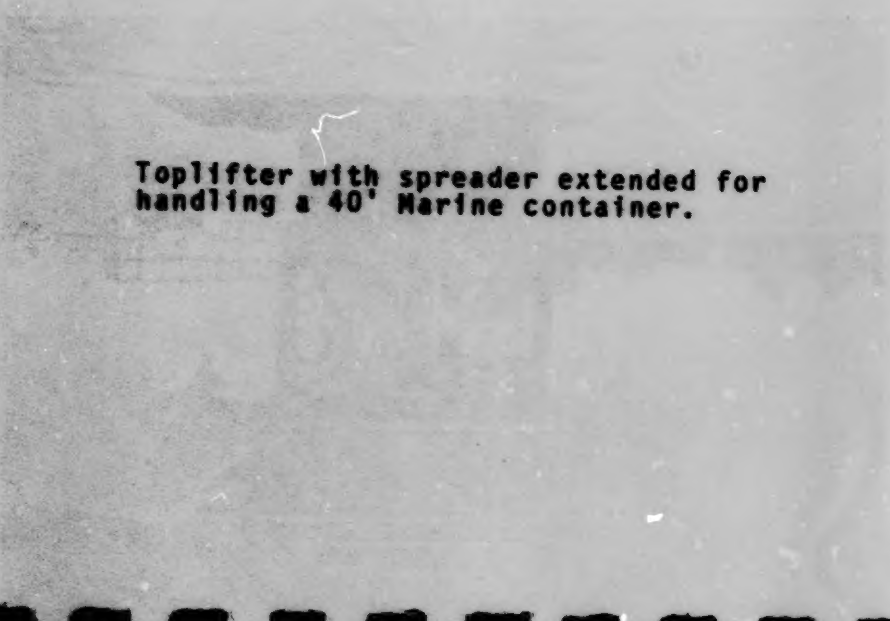




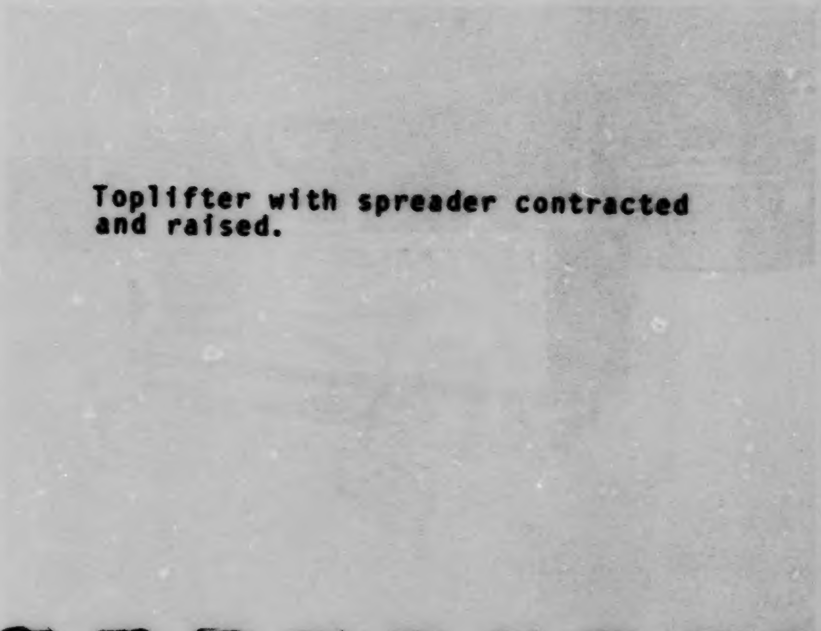
"Piggy Packer" for lifting
trailers onto and off of flat cars.



Toplifter loading a 44' domestic
container onto a flatcar.

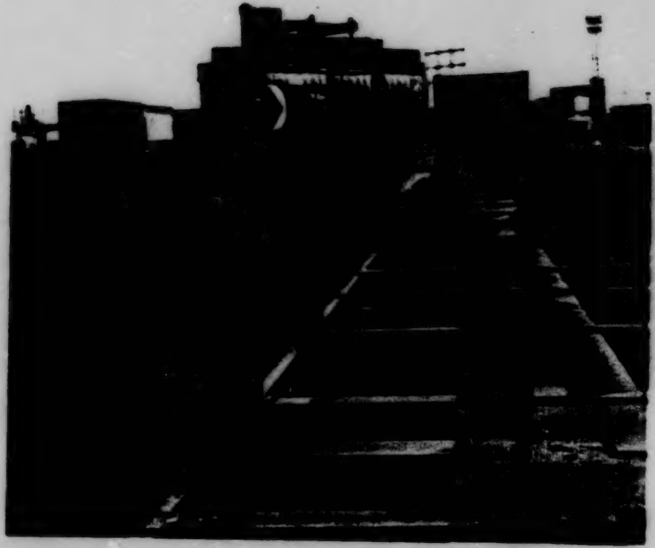


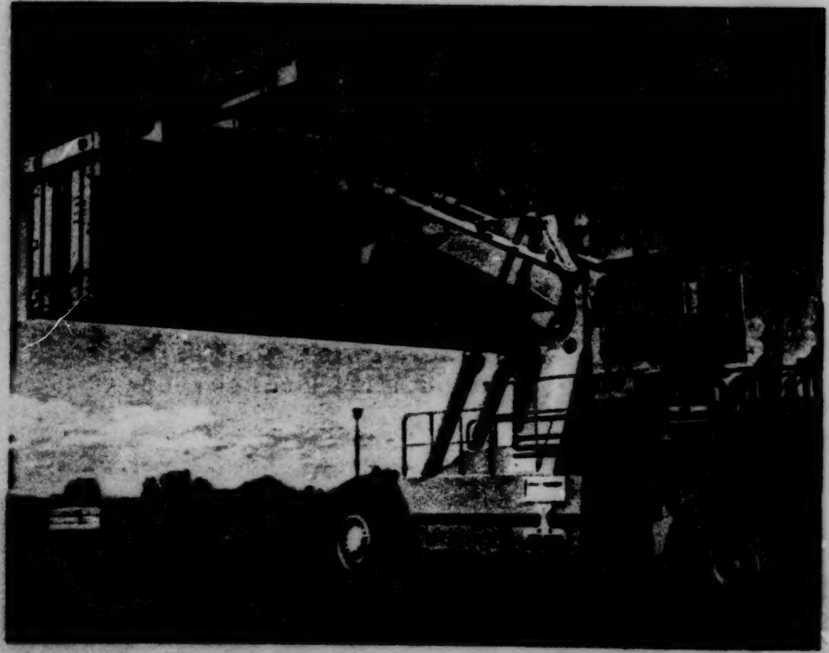
Toplifter with spreader extended for
handling a 40' Marine container.

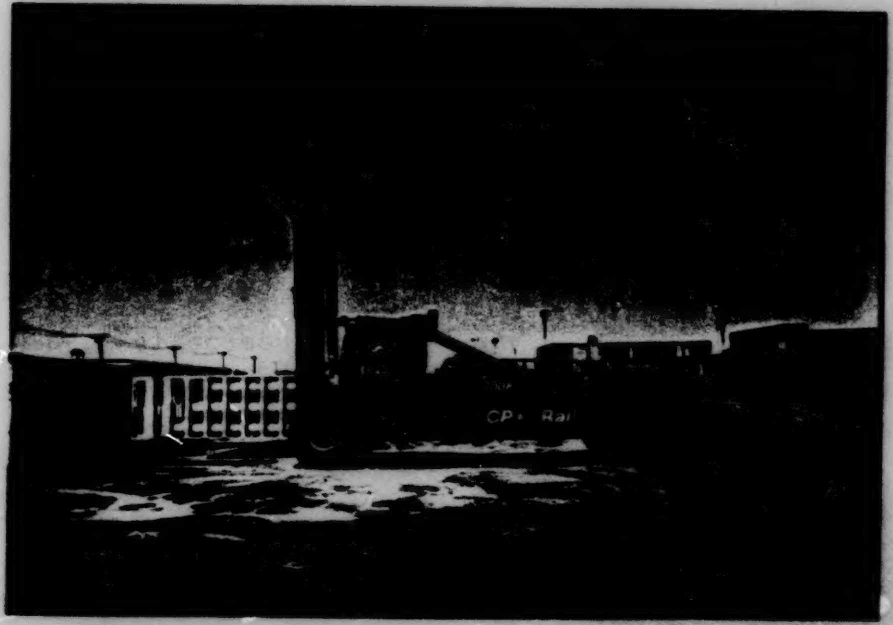


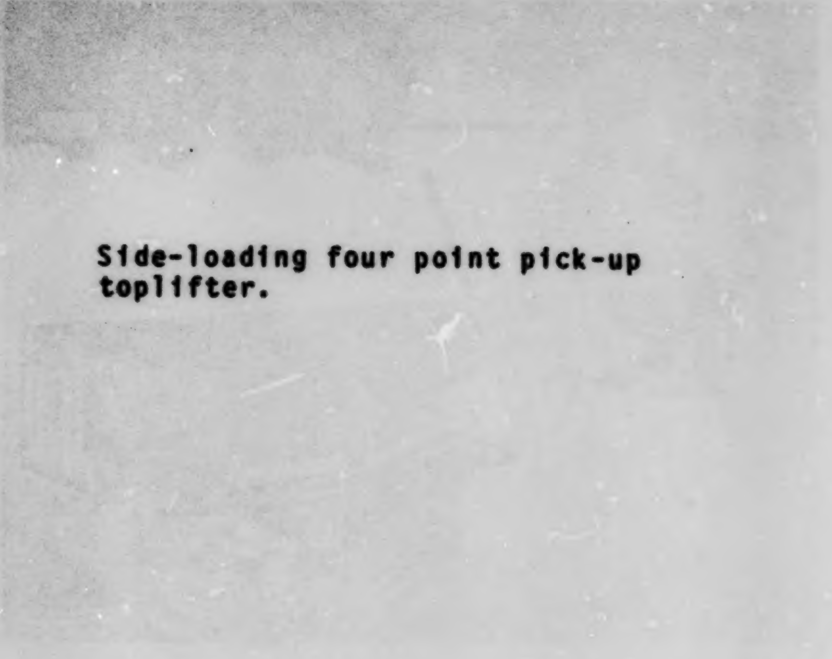
Toplifter with spreader contracted
and raised.

PACIFIC

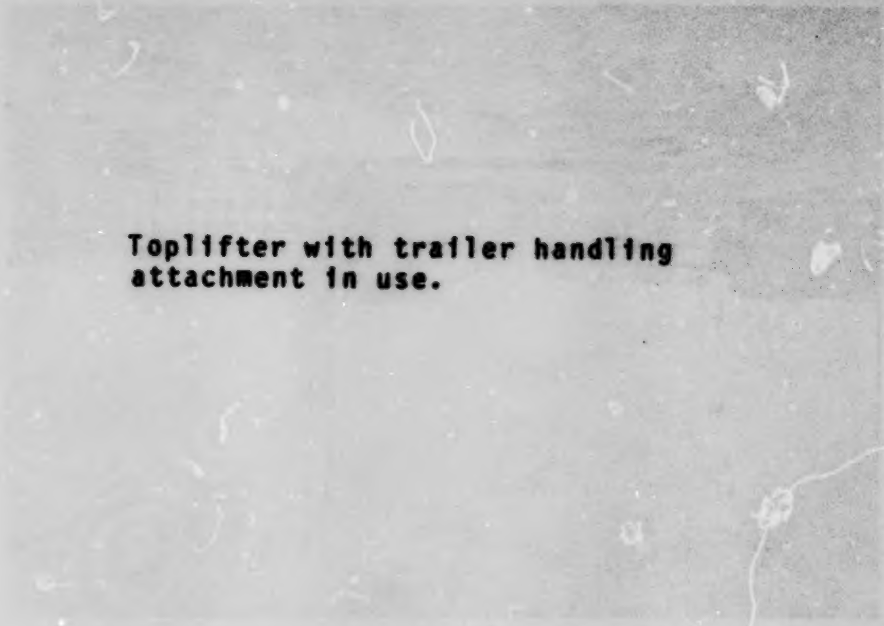




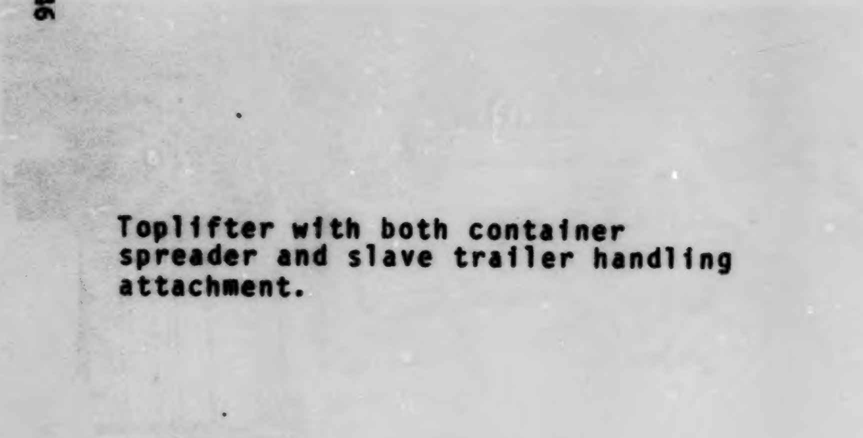

CP Rail



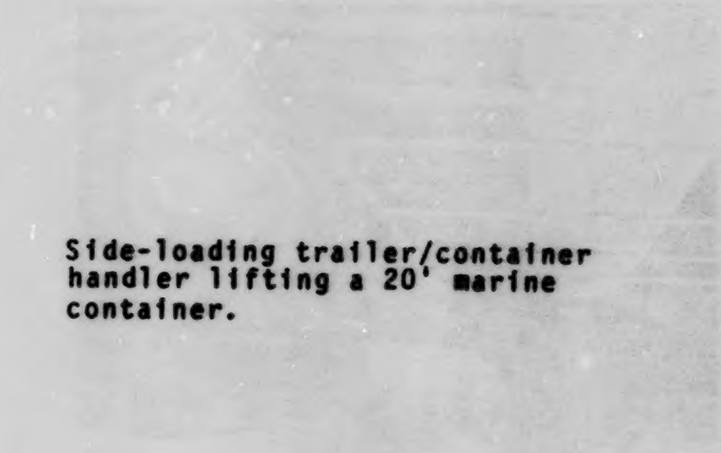
Side-loading four point pick-up toplifter.



Toplifter with trailer handling attachment in use.



Toplifter with both container spreader and slave trailer handling attachment.



Side-loading trailer/container handler lifting a 20' marine container.

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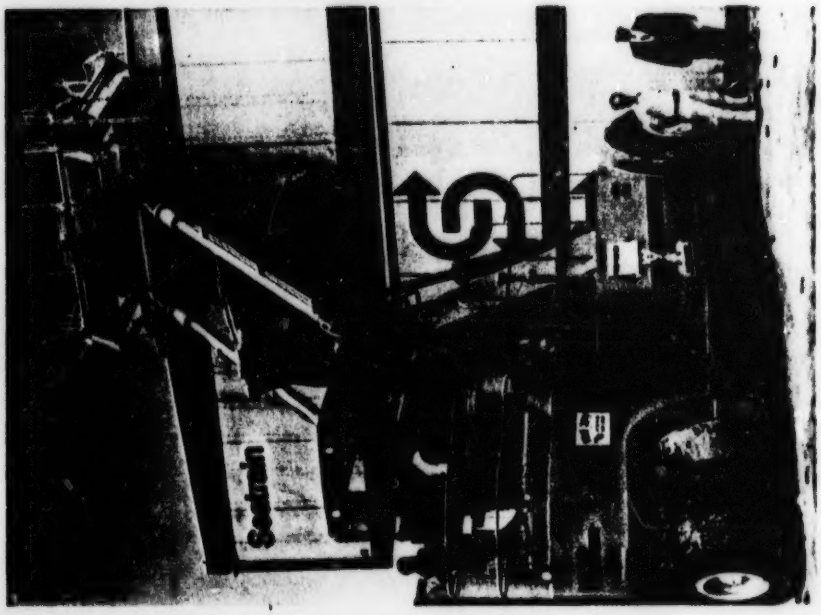
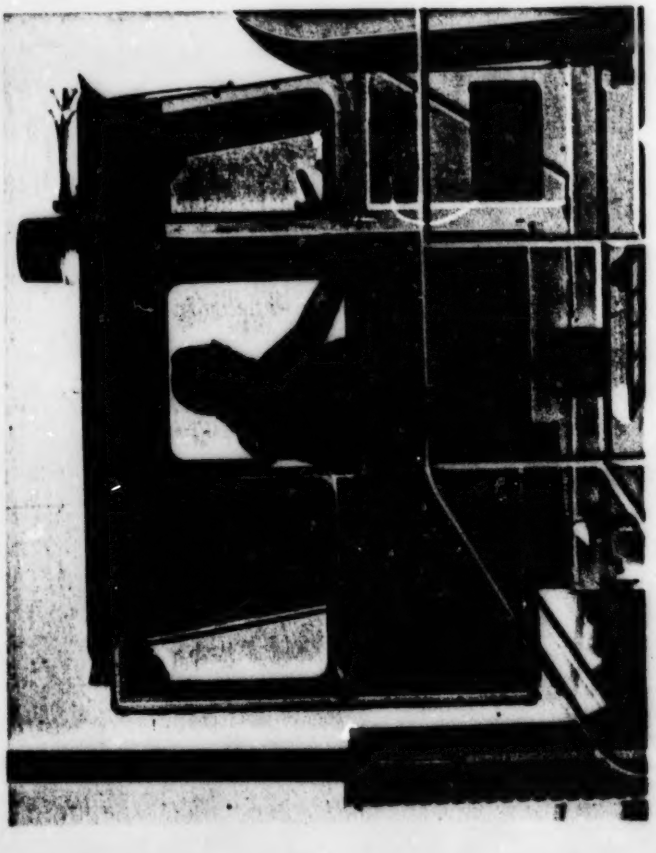
Close-up of a typical side-lifter
cab illustrating that 360 degrees of
visibility is provided.

Side-loading equipment stacks
40' marine containers 3 high.


Seatrain



SECTION 4

INTERMODAL TERMINAL EQUIPMENT FOR LOW-VOLUME OR SPECIAL APPLICATIONS

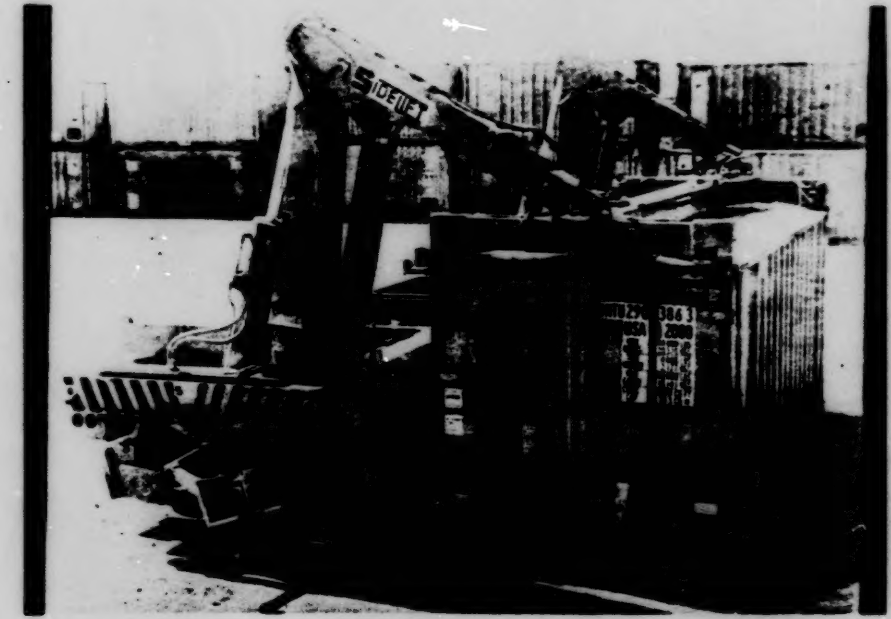
Rail car, side-loading equipment and container chassis. The container slides sideways off of the flat-car and onto the chassis.

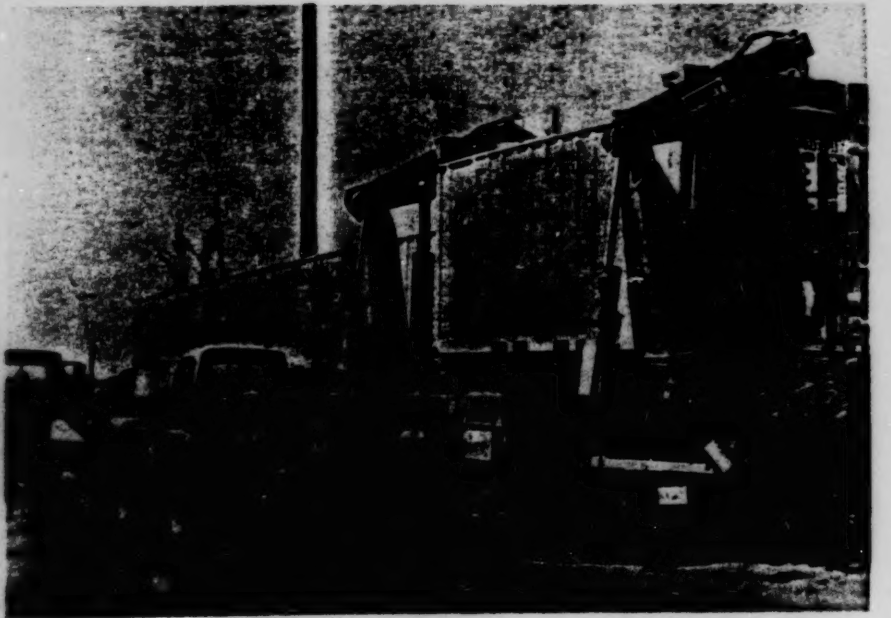
View of the equipment used to slide the container.

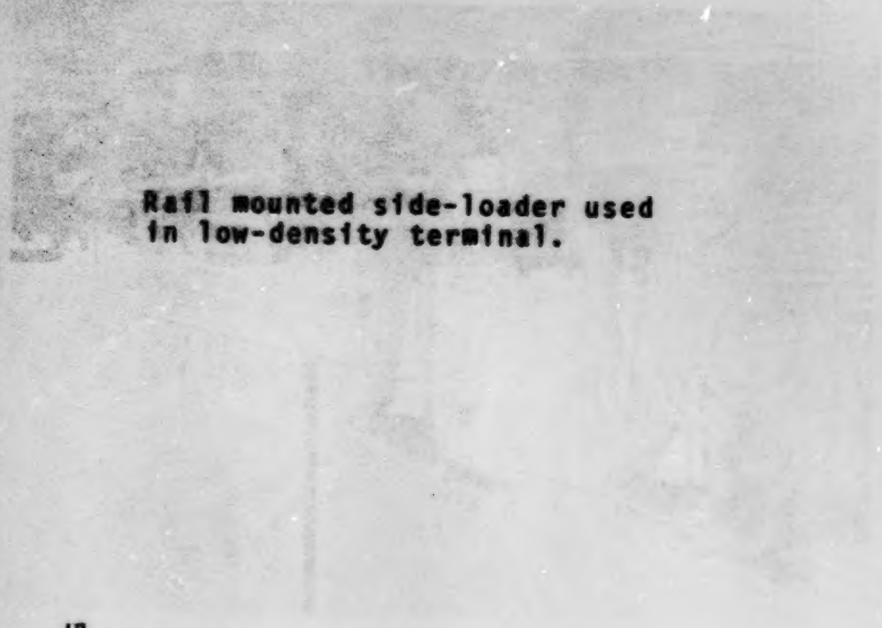
CP Rail

Different views of a side lift in operation. This equipment is used in low capacity terminals where containers can be loaded and unloaded from a flat-car and/or chassis. This sidelift can stack containers 2 high for storage.

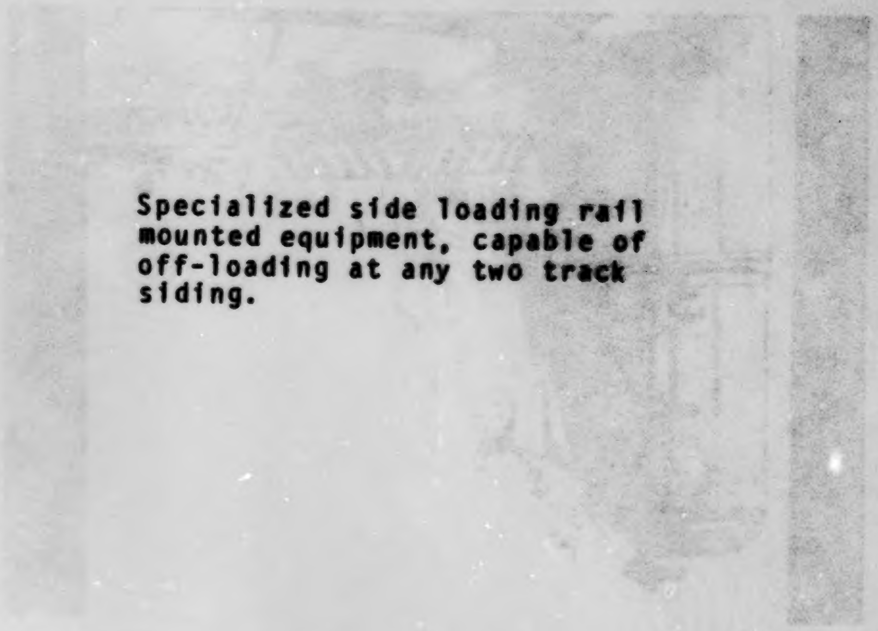
HAPAG





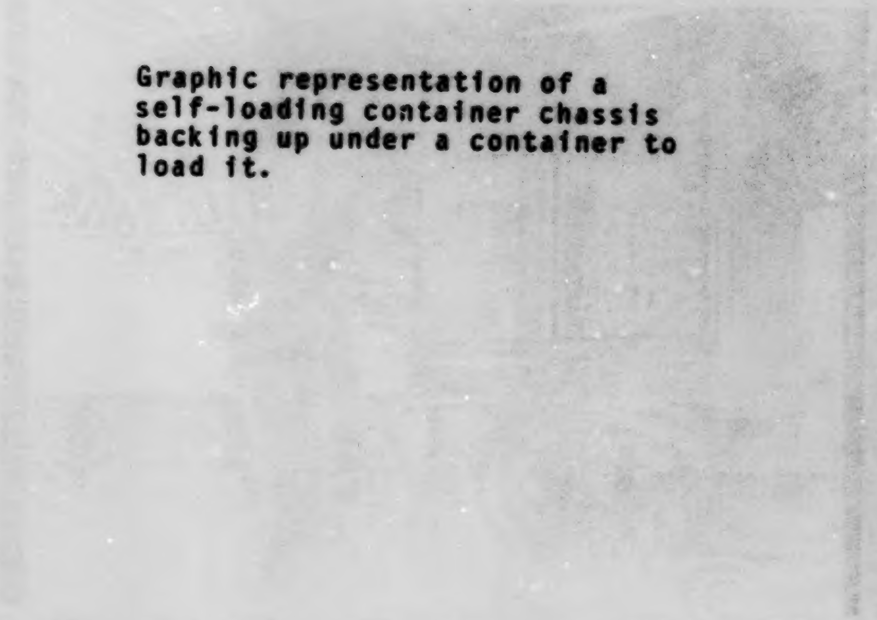


Rail mounted side-loader used in low-density terminal.

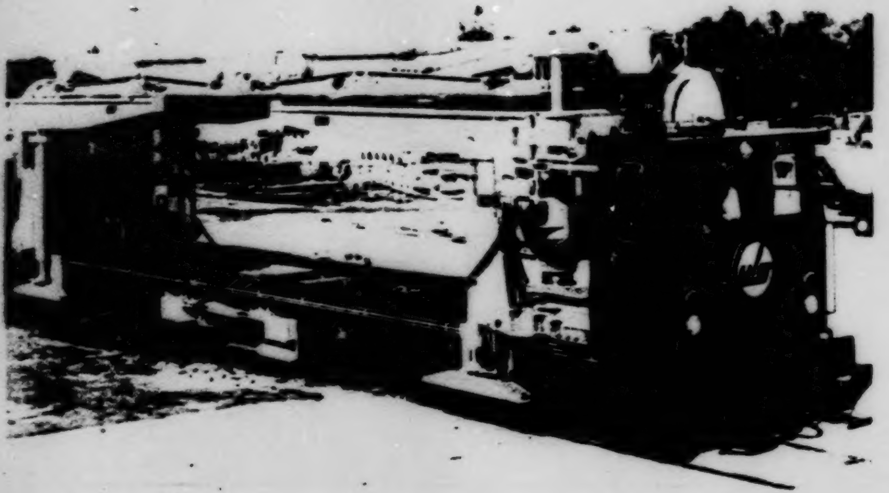


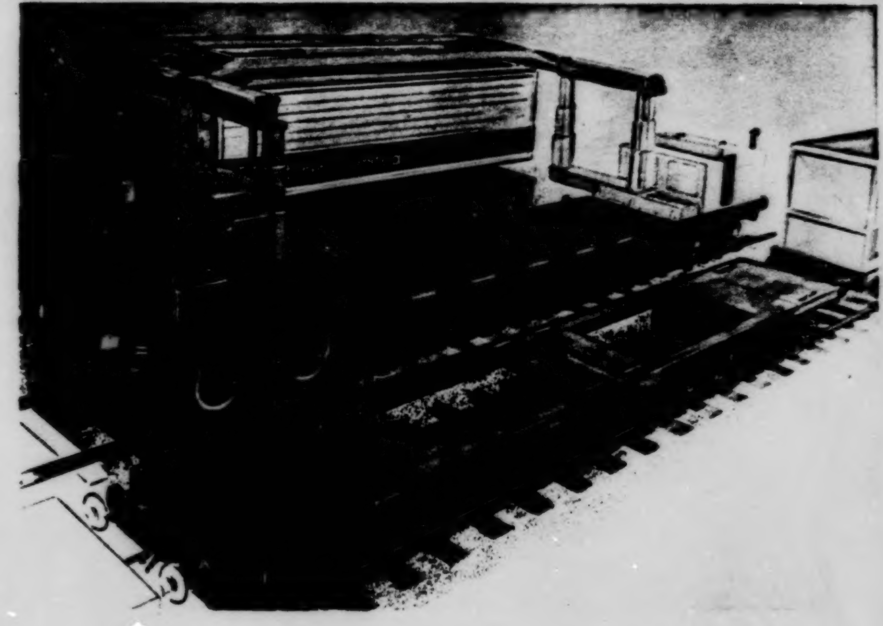
Specialized side loading rail mounted equipment, capable of off-loading at any two track siding.

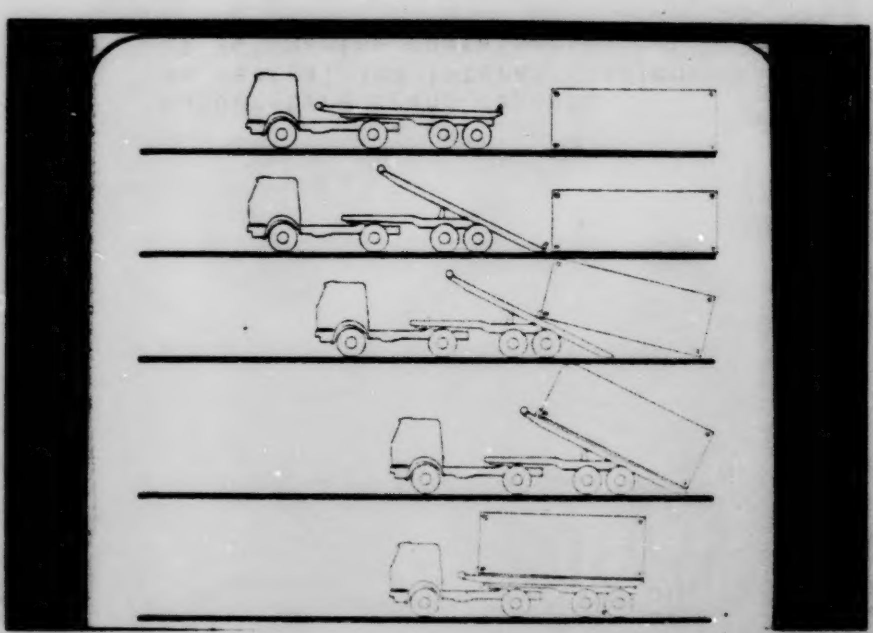
Specialized self-loading container chassis.

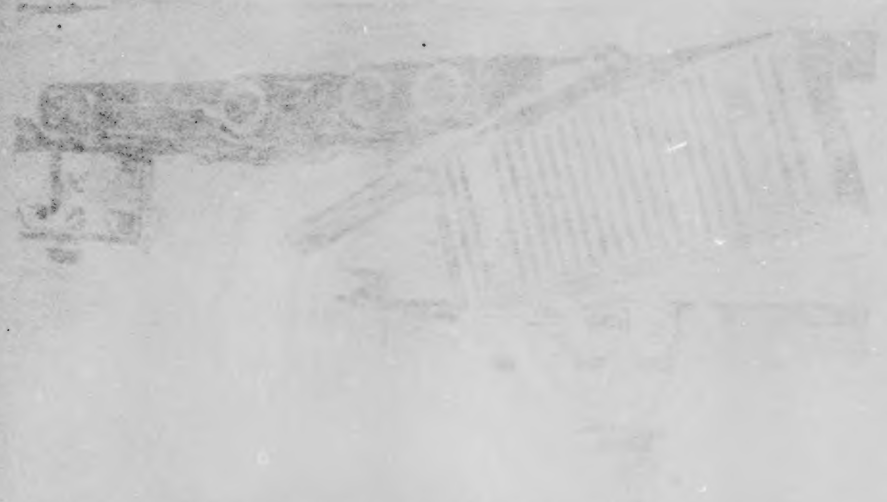


Graphic representation of a self-loading container chassis backing up under a container to load it.

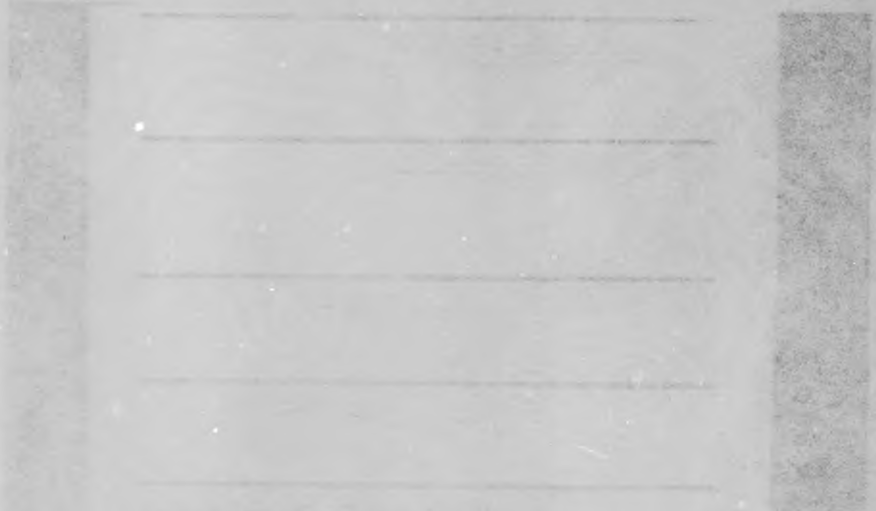




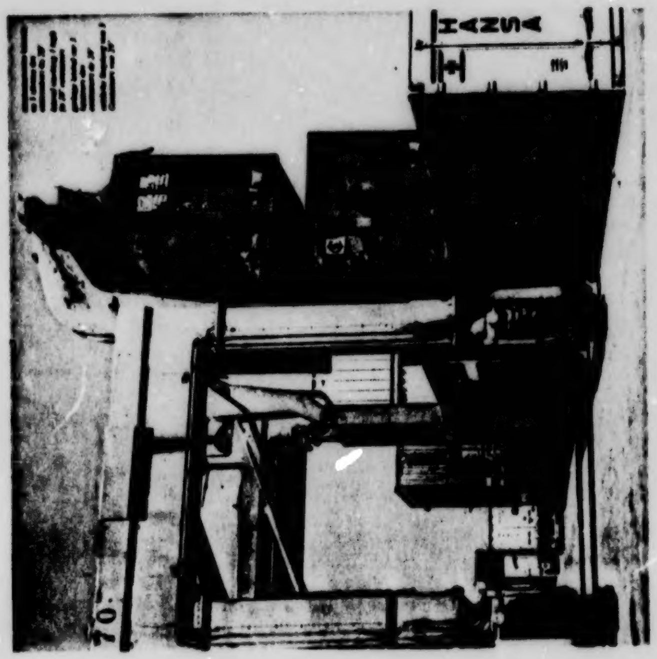




Rubber-tyre crane used for lateral and central loading of 40' marine containers.



Rubber-tyre crane capable of central and lateral loading of 20' marine containers.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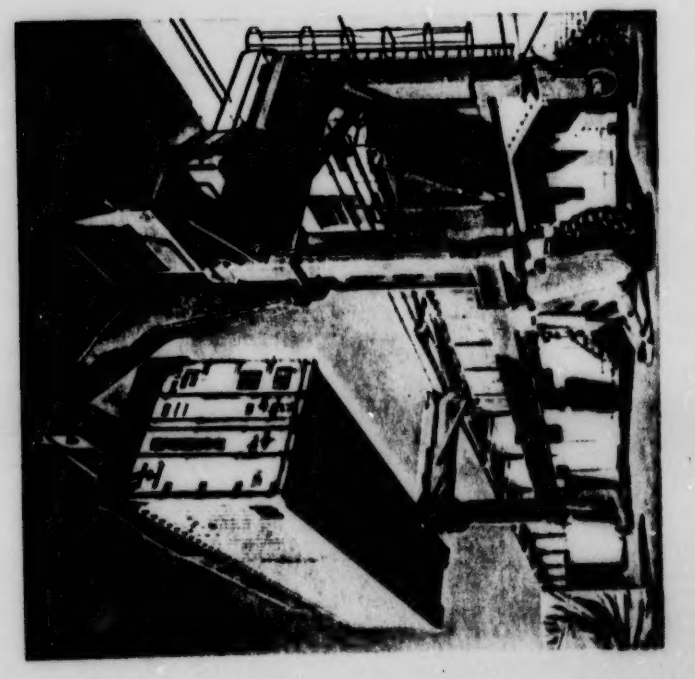


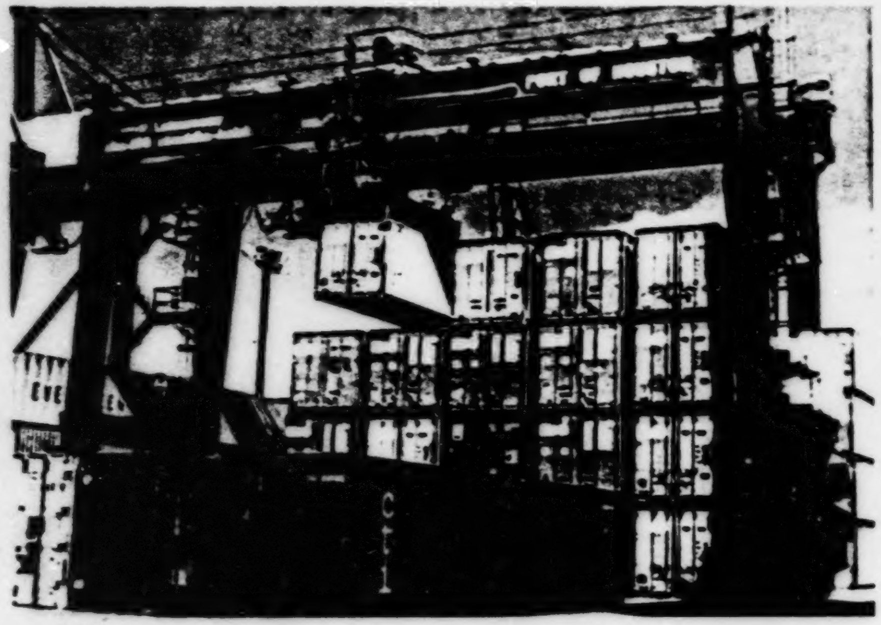
EQUIPMENT FOR INTERMODAL TERMINALS FOR HIGH RISE, HIGH DENSITY STORAGE AND RETRIEVAL SYSTEMS

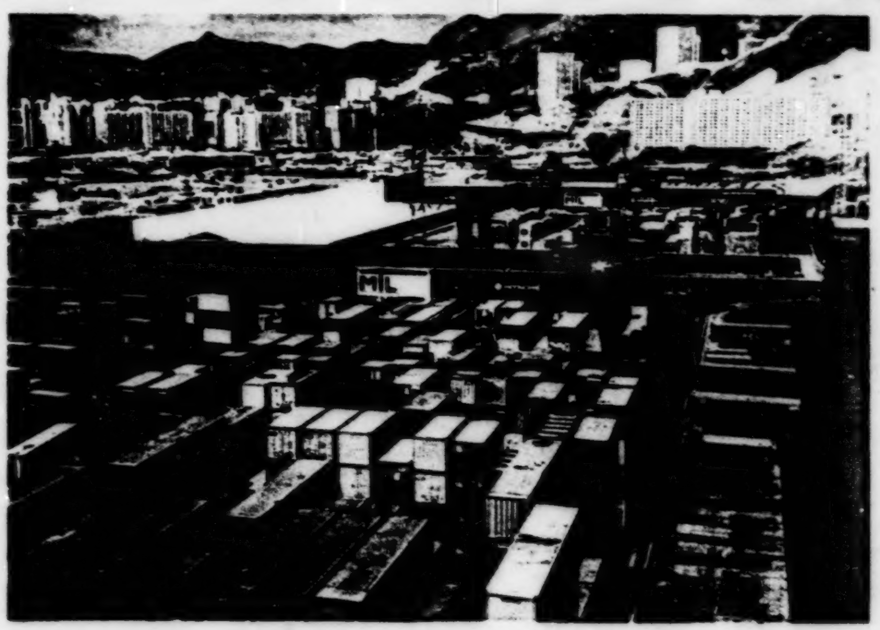
Rail mounted 0-6-0 Gantry Crane.

3-12-2 rail mounted Gantry Crane with two cantilevers.

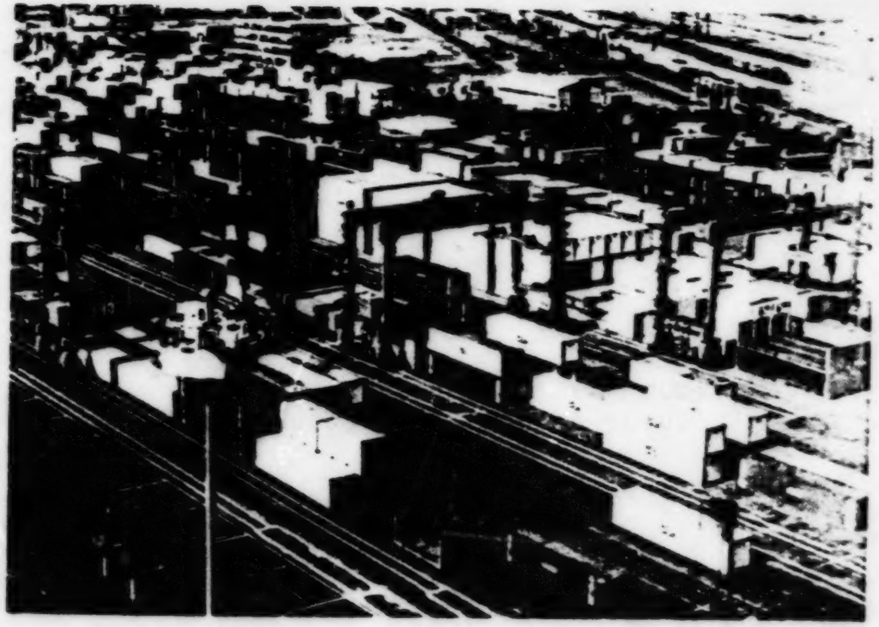
3-4-3 rail mounted Gantry Crane with two cantilevers used in a road/rail intermodal terminal

High-density terminal using three 0-6-0 cranes.





MIL



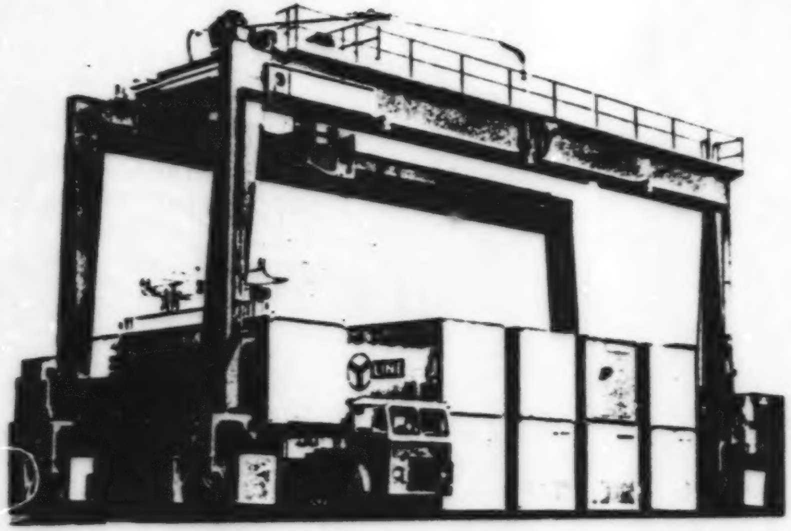
Rubber tyre - 0-5-0 crane used for stacking marine containers and loading on chassis.

Rail mounted 0-6-0 Gantry crane capable of stacking Marine Containers 4 high.

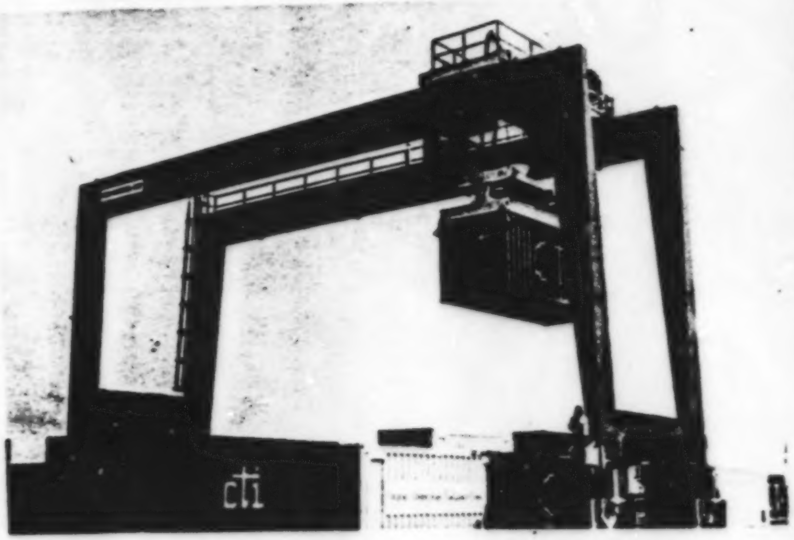
203 foot span rail mounted gantry crane with a cantilever.

Schematic explaining the X-X-X designation for gantry cranes with or without cantilevers sides.
-The first number designates the number of containers stacks or rails that fit under the left cantilever.
-The middle number relates to the number of stacks or tracks within the center span.
-The last number relates the right cantilever.

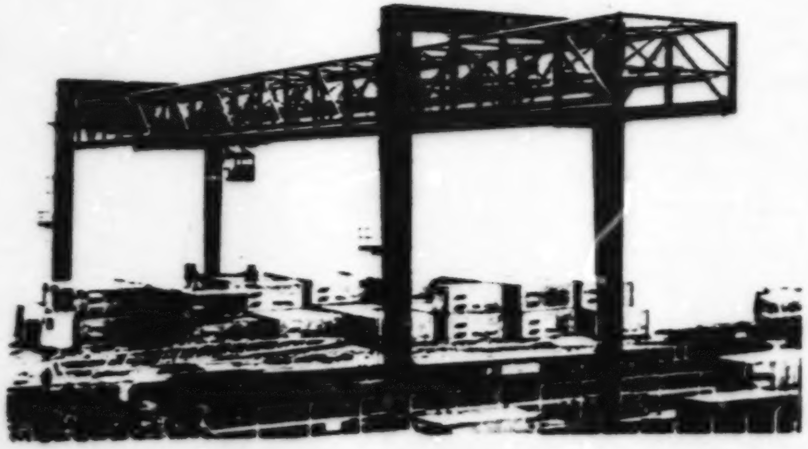
64 Foot Span—Three High Stacking

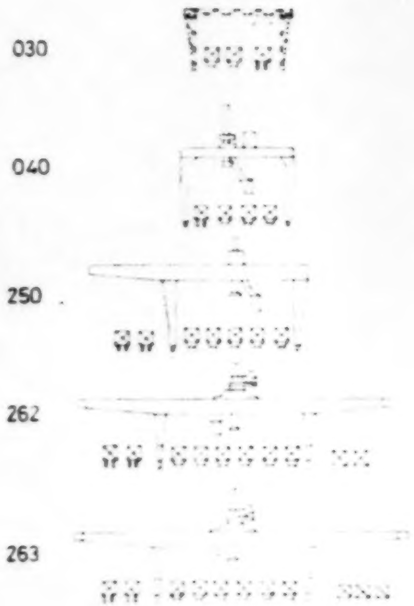


76 Foot Span—Four High Stacking



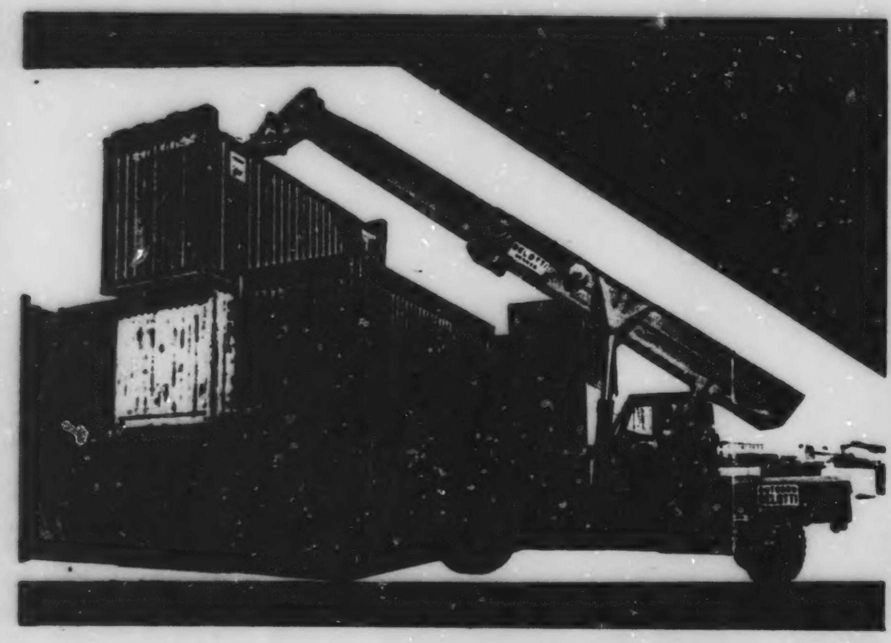
203 Foot Span with 38 Foot Cantilevers

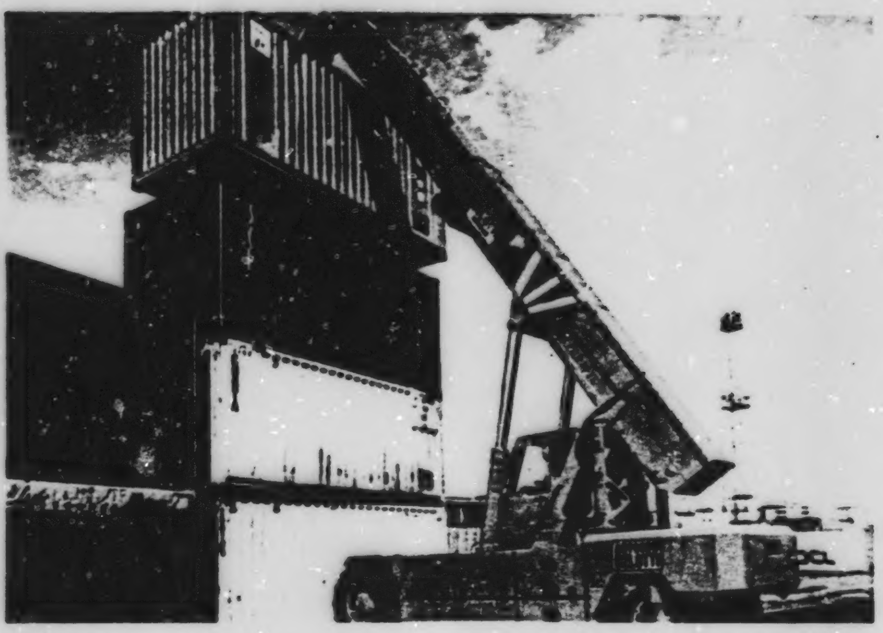


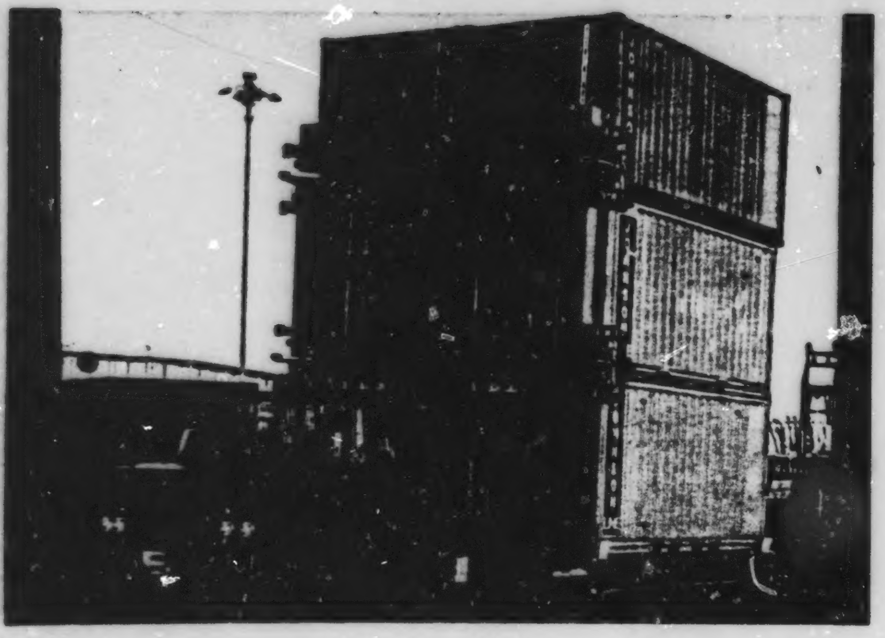

030
040
250
262
263

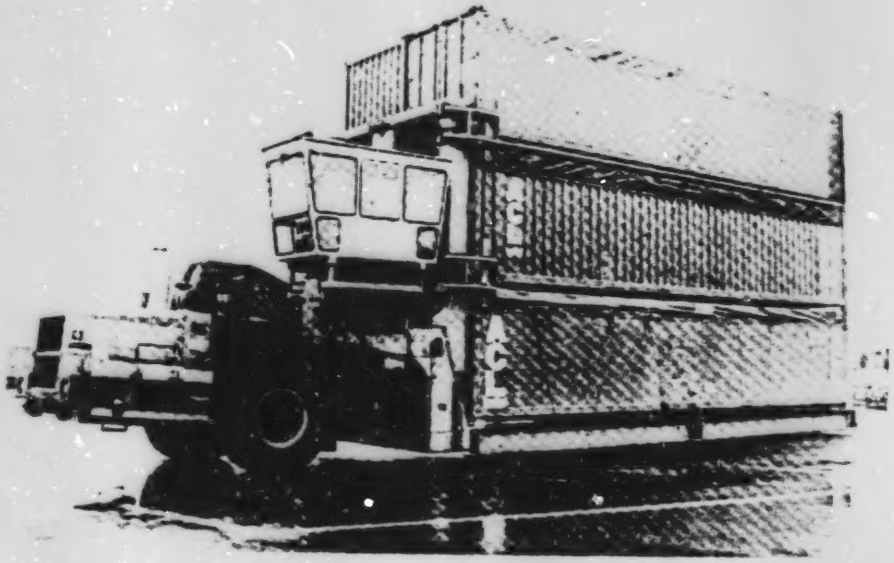
Boom crane with four point pick-up in operation stacking containers up to 4 high. The container typically can be pivoted so that the truck can operate in aisles narrower then the length of the container.

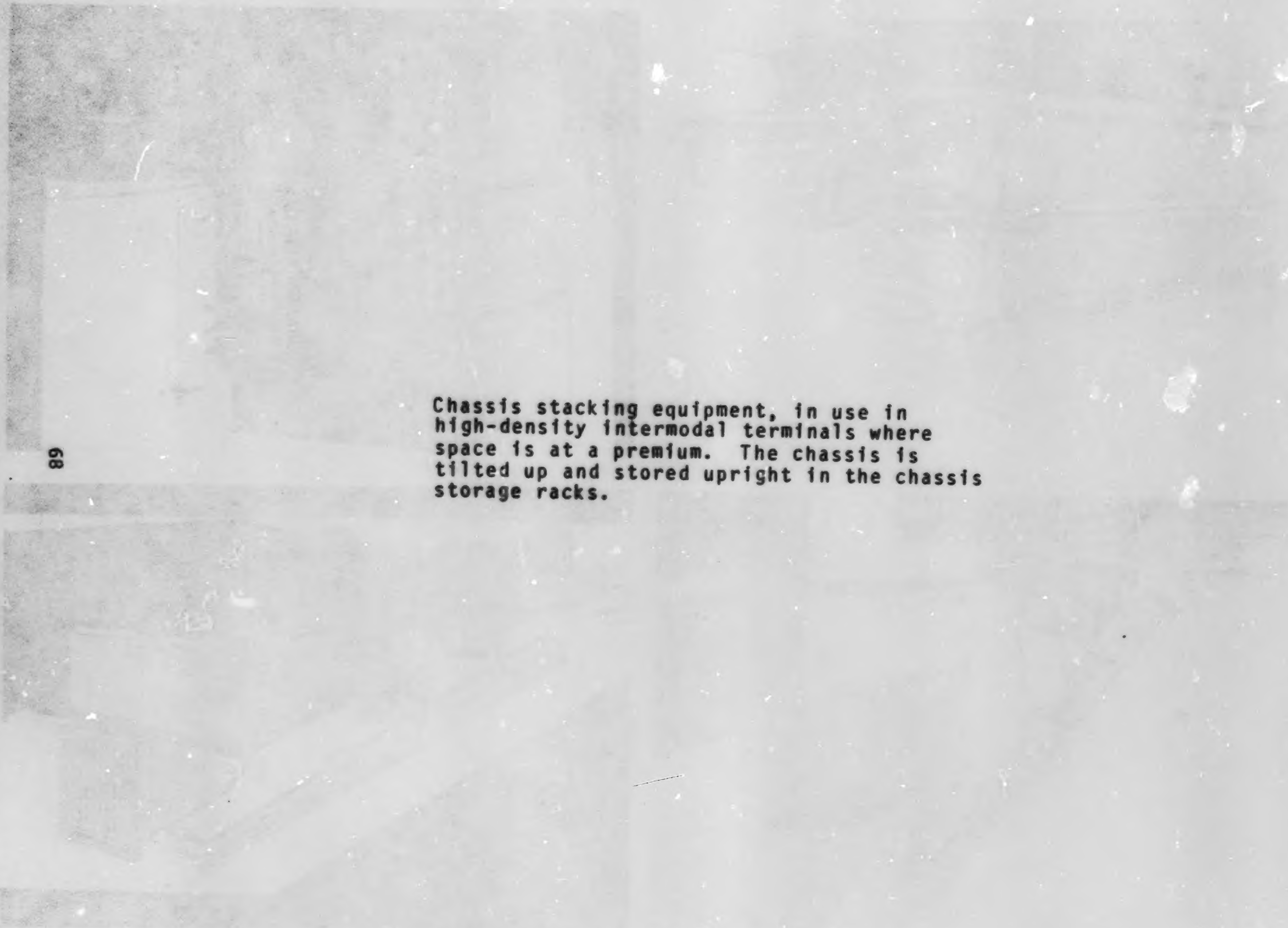
Multi-Container Hostling equipment used in transfer terminals where storage is not within the loading area.



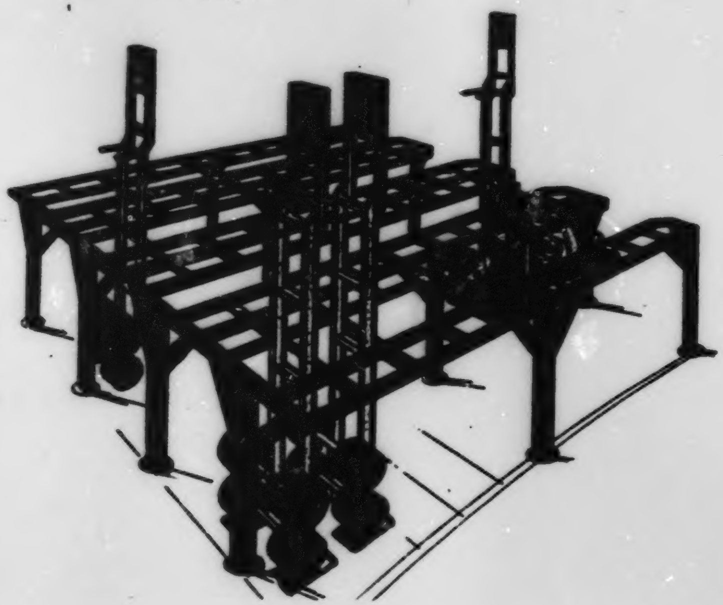


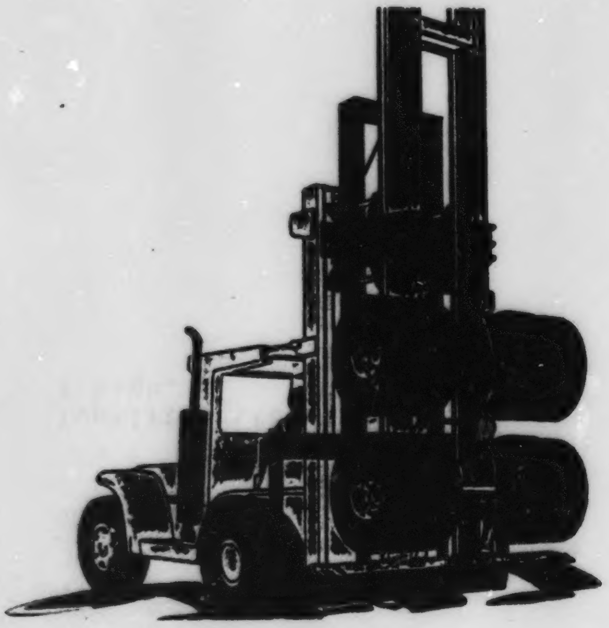


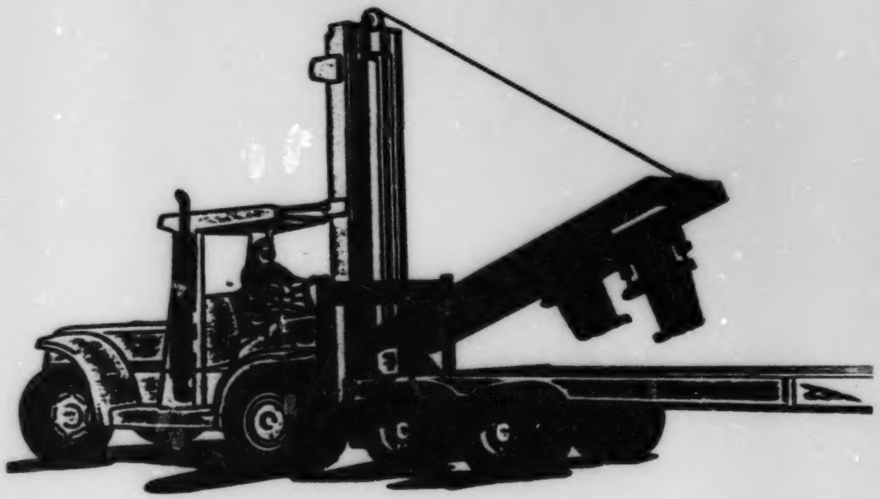


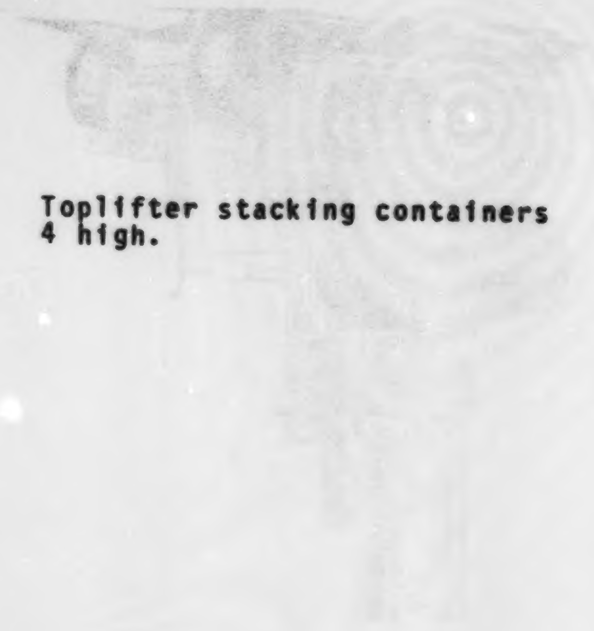


Chassis stacking equipment, in use in high-density intermodal terminals where space is at a premium. The chassis is tilted up and stored upright in the chassis storage racks.

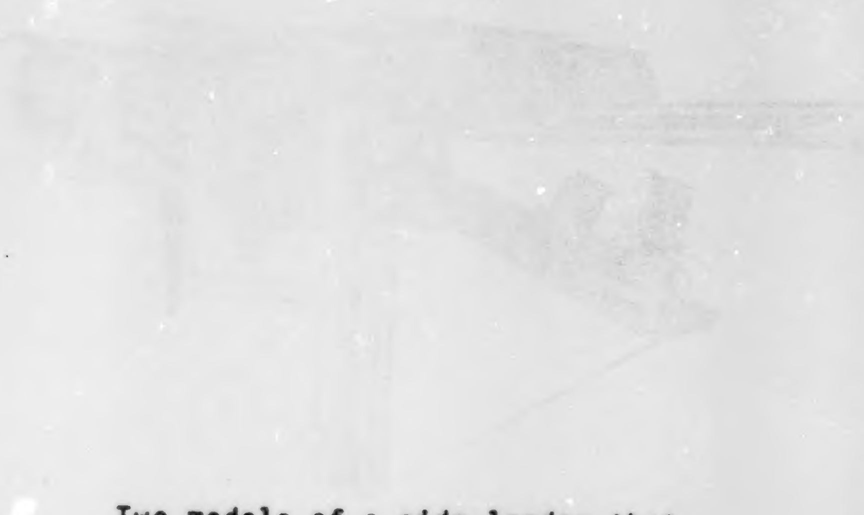






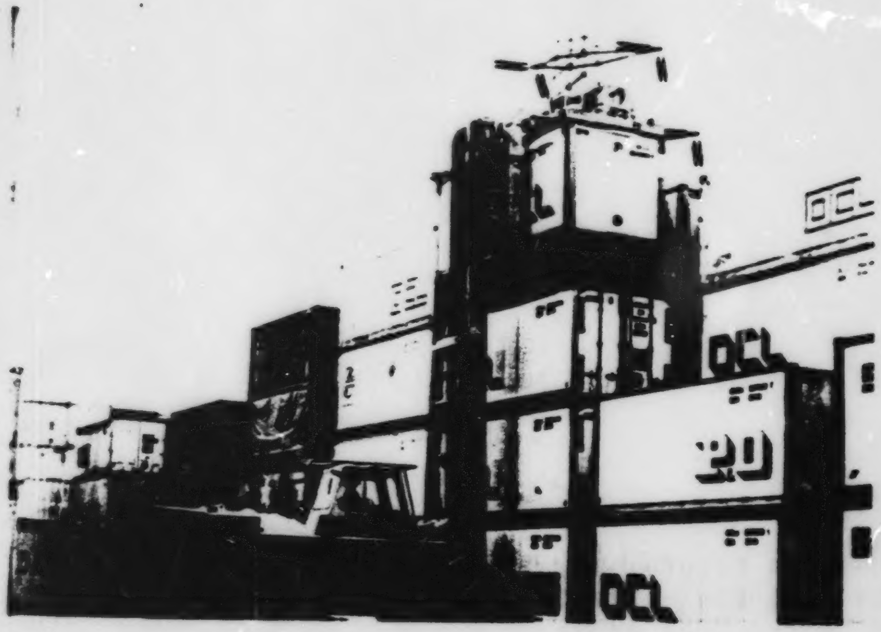


Toplifter stacking containers 4 high.



Two models of a side-loader that allow for random access of loaded containers in narrow aisleways.

Multi-container transfer equipment handling tank containers.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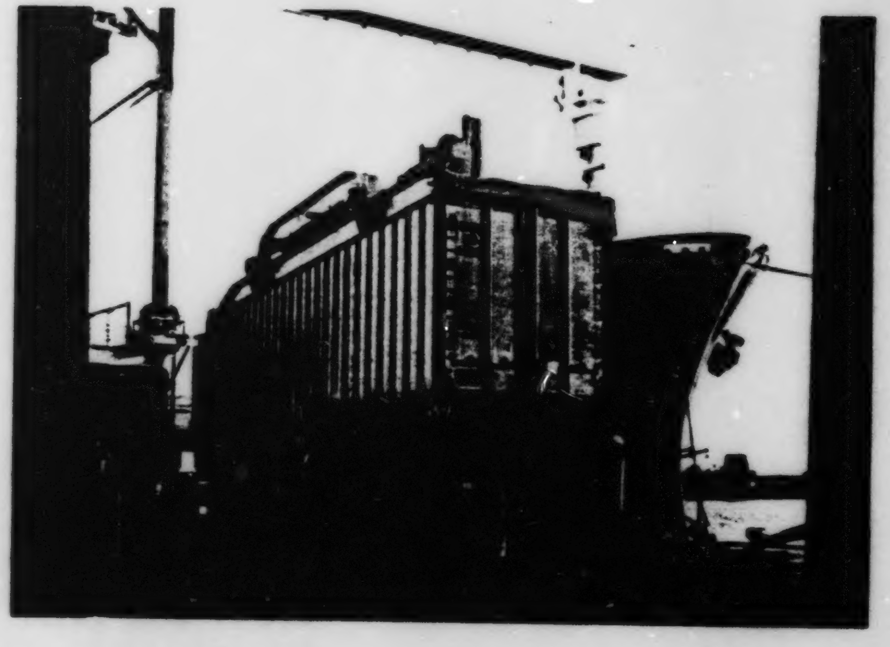
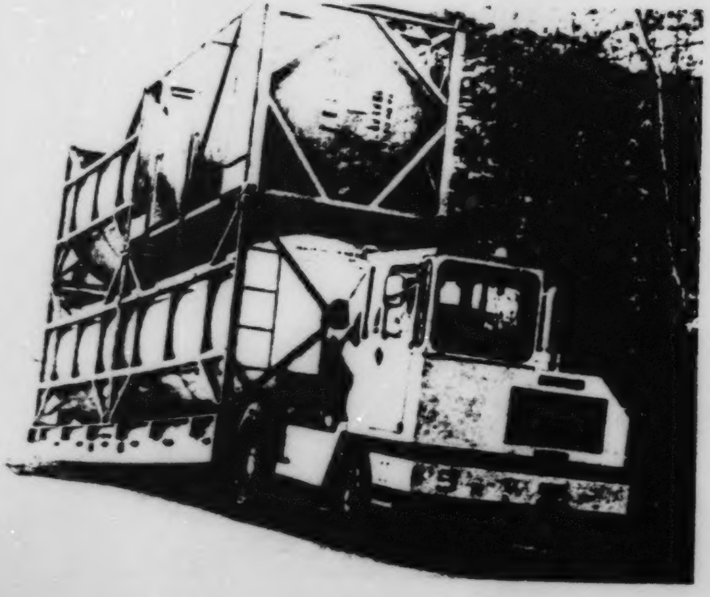
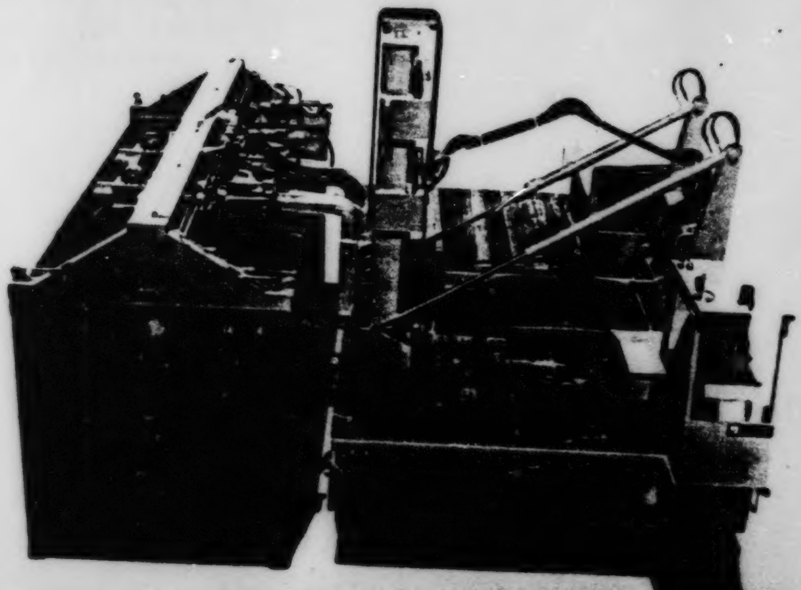
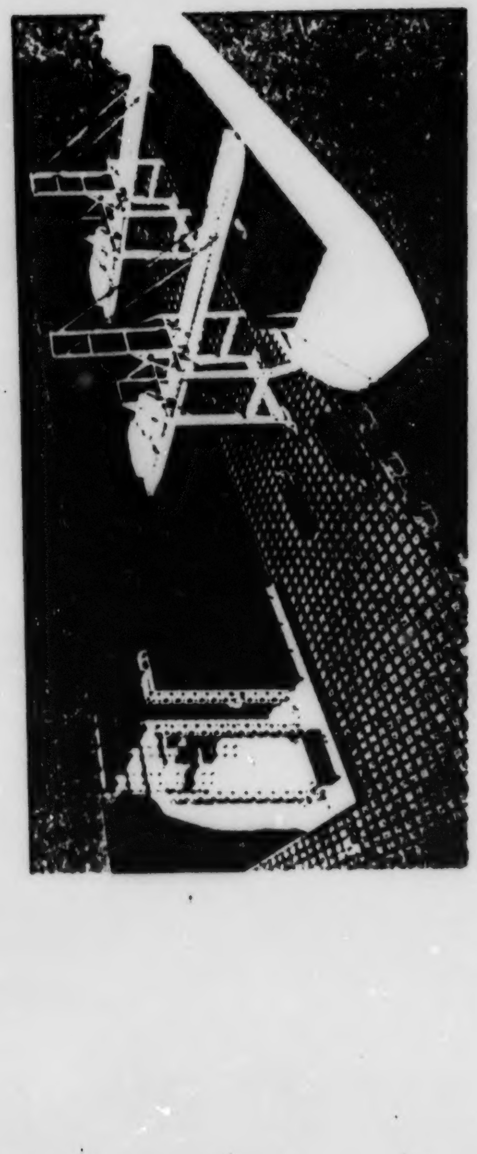
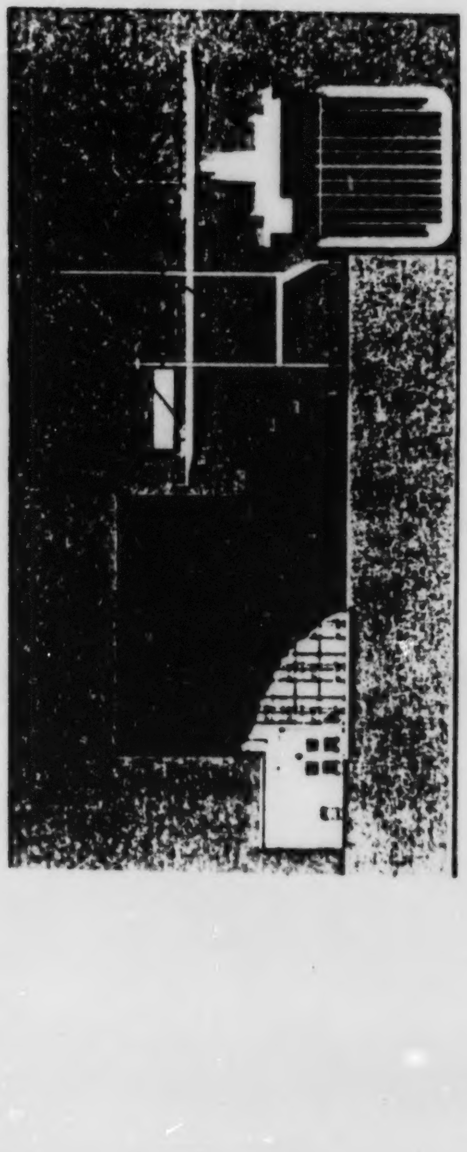


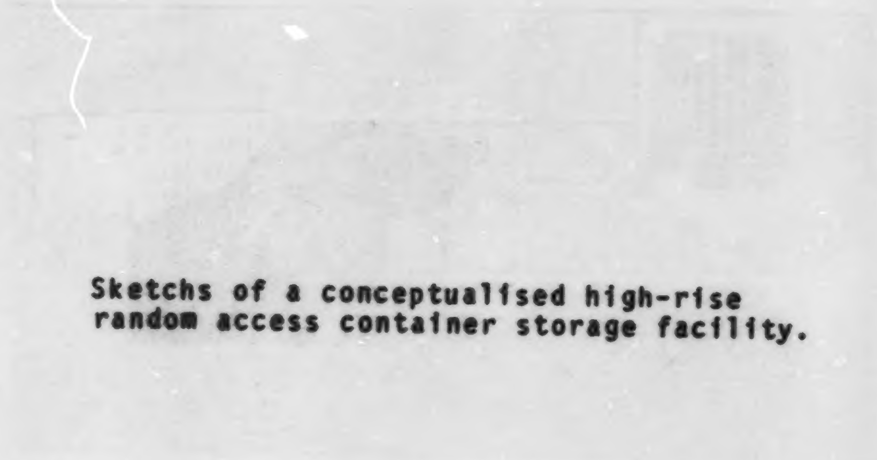




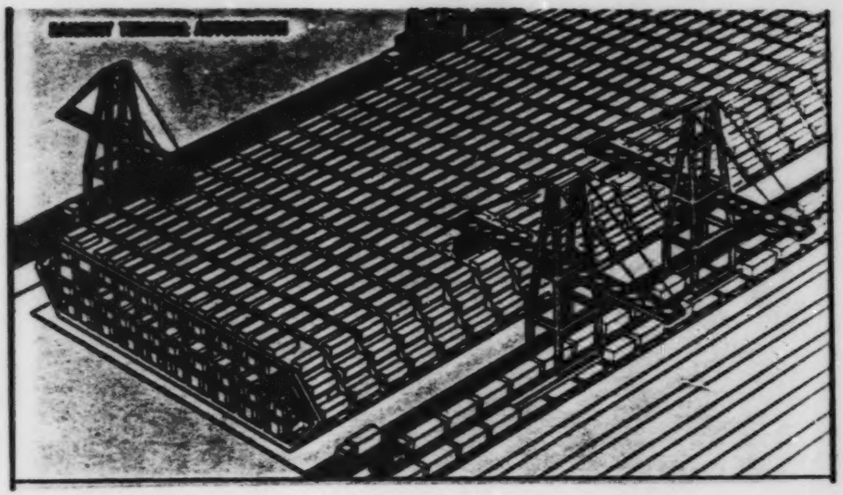
Mock-up of a high density random access storage facility. The large cantilever gantry crane can load and unload a ship of marine containers and store them in the building next to the crane. A cut-up view shows the facility for loading the container on chassis.

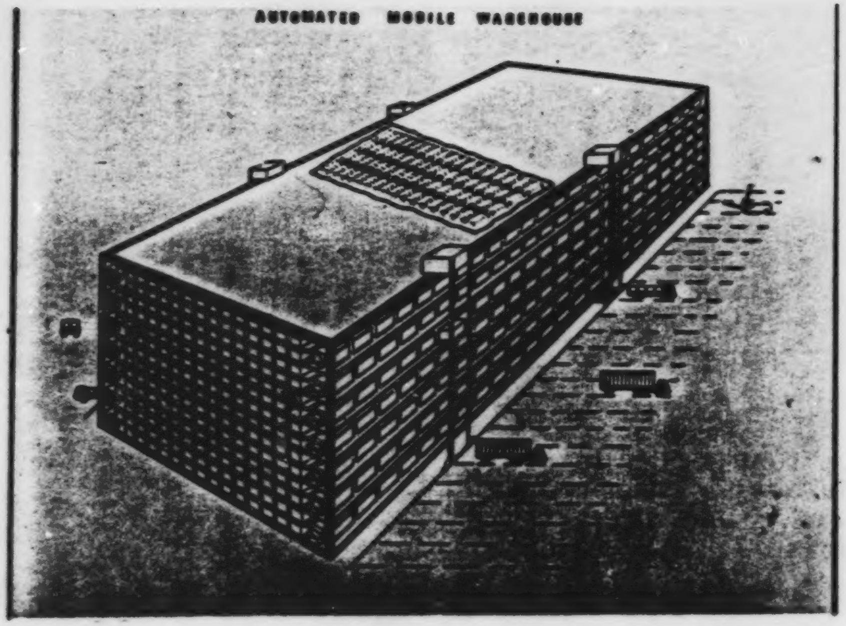


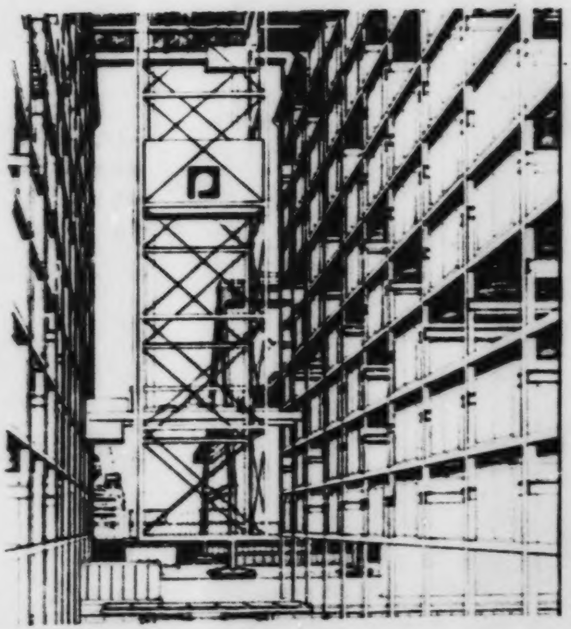




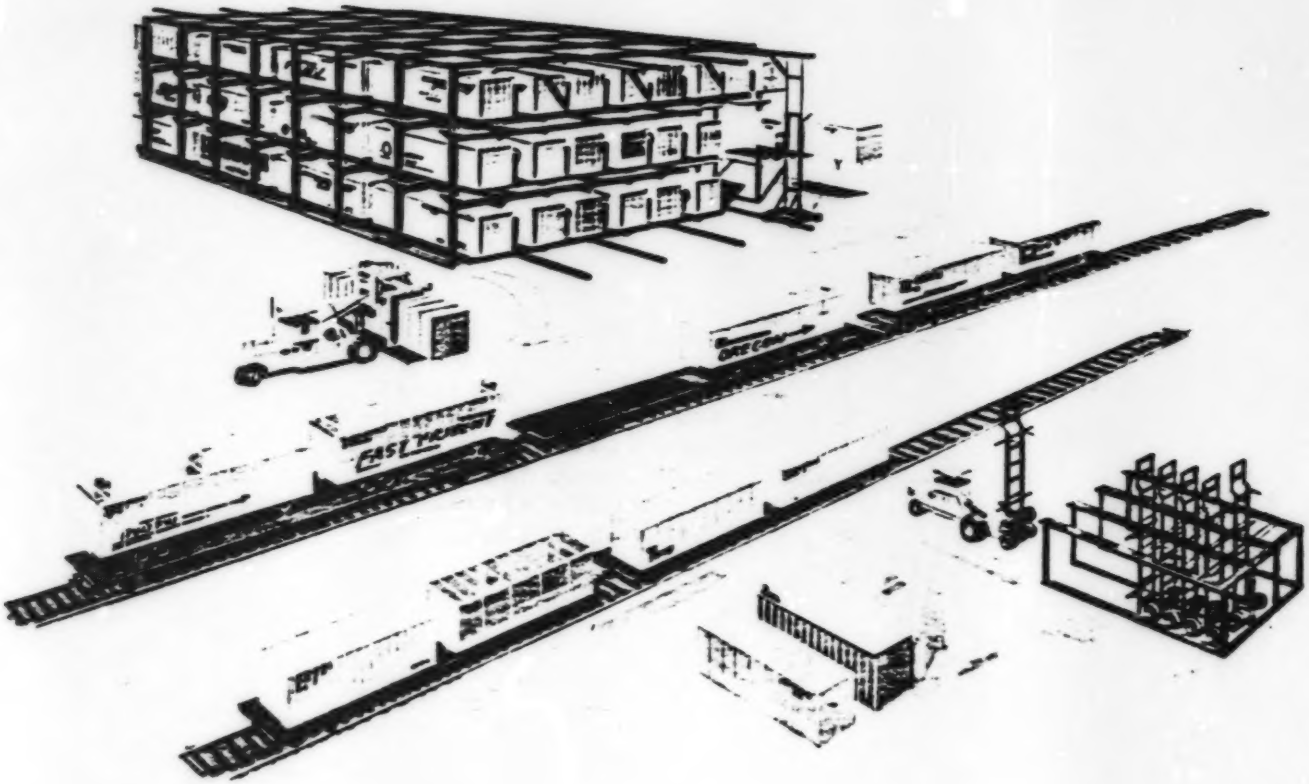
Sketchs of a conceptualised high-rise
random access container storage facility.




AUTOMATED MOBILE WAREHOUSE

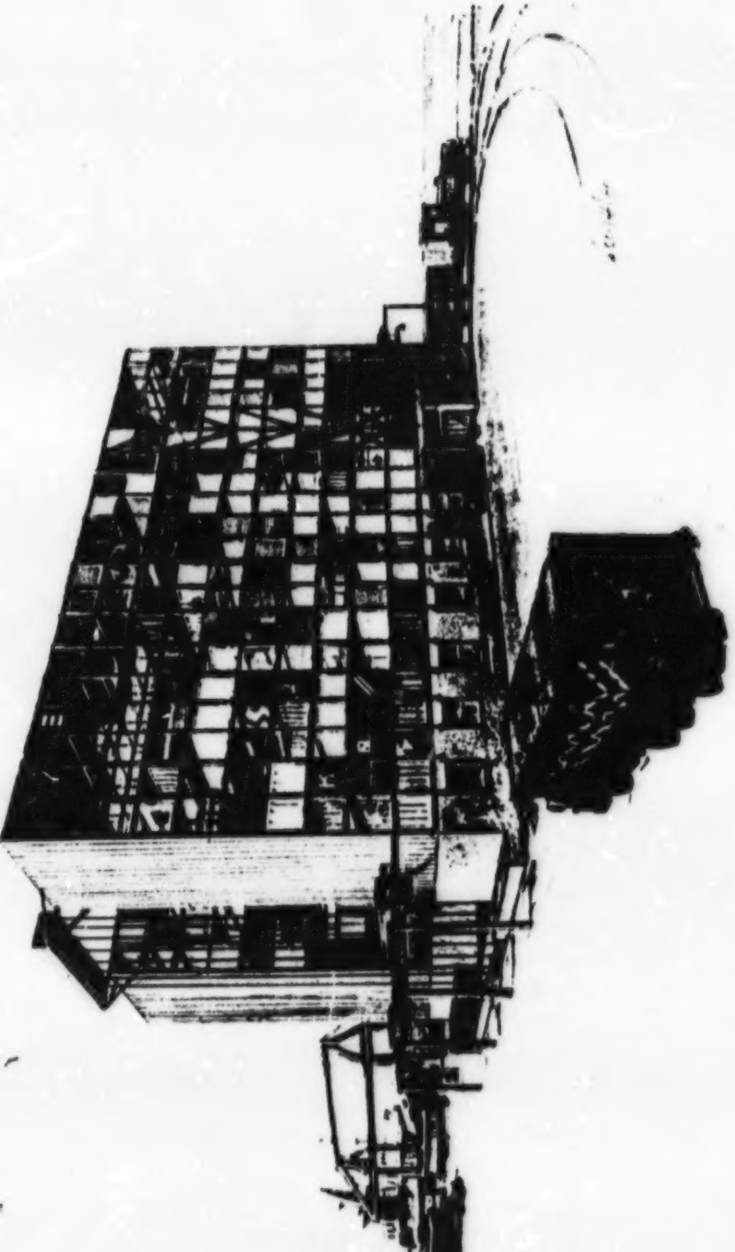


A high-density storage layout with facilities for 3 high trailer storage and chassis stacking. On site storage of containers is also available.


EAST TRANSIT
OREGON

①

An artist's conception of a high-rise random access container storage facility. In this sketch, trains, trucks and ships can be serviced.



An artist's conception of an automated container handling system. Trucks do not enter the terminal but are serviced at the inspection gates by the automated storage and retrieval system.